ol. XVII, No. 3
eptember, 1960

Eugene B. Power
Universal Microfilms
313 N. First St.
Ann Arbor, Mich.
-1

INDUSTRIAL QUALITY CONTROL

QUALITY
through
Scientific
Methods

JOURNAL OF THE AMERICAN SOCIETY FOR QUALITY CONTROL

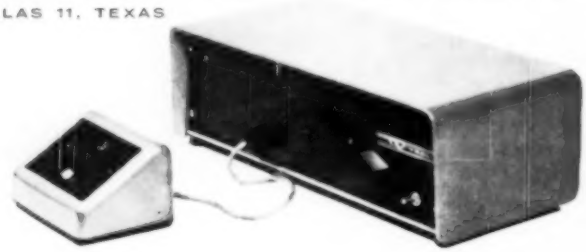
texas electronic products corp.

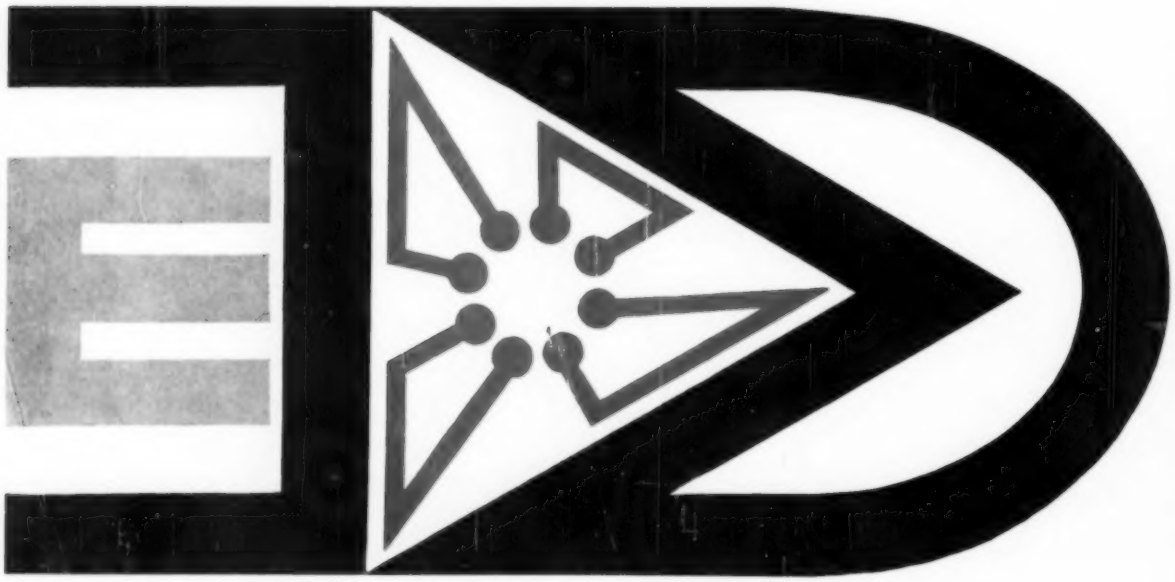
5114 WEST JEFFERSON BLVD. • DALLAS, TEXAS

We'd like to let you know that our name has been altered to catch up with our expanding activities. Diversa Electronics is a name more indicative of our diverse creative activity. Among our proud creations is Q-trol, a major break-through in quality control. Q-trol is an electronic brain which mechanizes Wald's Theory of sequential analysis. It is a digital computer capable of receiving, remembering and acting upon quality control information fed into its memory. Its deductions are accurate and instantaneous. Management is constantly aware of inferior goods being received or manufactured. Remarkably, Q-trol is capable of service in hundreds of industries ranging from the very small to the very large. Any time inspecting and sampling are involved, Q-trol can excel. Moreover, the cost of Q-trol and its simple operation almost invariably is less than the cost of conventional methods. Invite Q-trol into your organization. Share the good fortune of those who get the quality they want and at lower costs. Write, wire or call for a free illustrated brochure.

DIVERSA ELECTRONICS

5114 WEST JEFFERSON BLVD. • FE 9-9351 • DALLAS 11, TEXAS



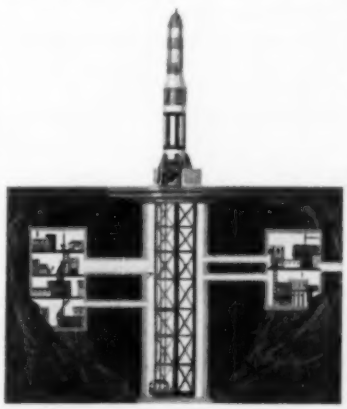


ASSIGNMENT: HIT A TARGET 6000 MILES AWAY

Can you guide a 110-ton Air Force Titan missile far up into the sky, to bring its nuclear warhead down with pinpoint accuracy on a target one-fourth the way around the globe—a target you not only can't see but which continually moves with the spinning earth?

This was the problem in missile guidance the Air Force presented to Bell Telephone Laboratories and its manufacturing partner, Western Electric. The answer was the development of a command guidance system which steers the Titan with high accuracy.

Unlike self-contained systems which demand complex guidance equipment in the missile itself, Bell Laboratories' Command Guidance System keeps its master control equipment on the ground where it can be used over and over again. Thus a minimum of equipment is carried in the missile, and the ground station has full control of the missile during its guided flight. Techniques drawn from the communications art render the system immune to radio jamming.



Bell Laboratories scientists and engineers designed the transmission and switching systems for the world's most versatile telephone network, developed much of our nation's radar, and pioneered in missile systems. From their vast storehouse of knowledge and experience comes the guidance system for the Titan.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

Editorial Board

MASON E. WESCOTT, *Chairman*
Rutgers • The State University, New Brunswick, N. J.

RICHARD S. BINGHAM, JR.
The Carborundum Co.

IRVING W. BURR
Purdue University

CECIL C. CRAIG
University of Michigan

HAROLD F. DODGE
Rutgers • The State University

A. V. FEIGENBAUM
General Electric Co.

ENOCH B. FERRELL
Bell Telephone Laboratories

FRANK E. GRUBBS
Aberdeen Proving Grounds

DAME S. HAMBY
North Carolina State College

CHARLES R. HICKS
Purdue University

HOWARD L. JONES
University of Chicago

LLOYD A. KNOWLER
State University of Iowa

GERALD J. LIEBERMAN
Stanford University

GAYLE W. MCELRATH
University of Minnesota

CARL E. NOBLE
Kimberly-Clark Corp.

MARY N. TORREY
Bell Telephone Laboratories

1960-61 Society Officers

President
J. Y. MCCLURE
Convair Div. of
General Dynamics Corp.
Fort Worth, Texas

Vice Presidents
L. S. EICHELBERGER
A. O. Smith Corp.
Milwaukee, Wis.

A. V. FEIGENBAUM
General Electric Co.
New York, N. Y.

A. B. MUNDEL
Sonotone Corp.
Elmsford, N. Y.

WARREN R. PURCELL
Raytheon Mfg. Co.
Newton, Mass.

Executive Secretary
DAVID S. CHAMBERS
University of Tennessee
Knoxville, Tenn.

Treasurer
R. L. FIASCHETTI
Ansco General Aniline &
Film Corp.
Binghamton, N. Y.

Junior Past President
C. E. FISHER
Bell Telephone Laboratories
New York, N. Y.

1960-61 Executive Directors

H. D. BIRCH
General Electric Co.
Cincinnati, Ohio

P. S. OLMSTEAD
Bell Telephone Laboratories
Murray Hill, N. J.

H. C. TODT
North American Aviation
Los Angeles, Calif.

I. W. SCHOENINGER
Globe Union, Inc.
Milwaukee, Wis.

A. W. WORTHAM
Texas Instruments, Inc.
Dallas, Texas

Advisory Council

E. U. CONDON, *Chairman*
Department of Physics
Washington University
St. Louis, Missouri

M. HERBERT EISENHART, *Retired*
Bausch & Lomb Optical Co.
Rochester, New York

HEPMON F. SAFFORD, *President*
Ohio Rubber Co.
Willoughby, Ohio

WALTER A. SHEWHART, *Retired*
Bell Telephone Laboratories
Murray Hill, New Jersey

Divisions of ASQC

Administrative Applications Division
E. T. MAGRUDER
Chesapeake Potomac
Telephone
Washington, D. C.

Aircraft & Missile Division
D. R. ARCHIBALD
Convair, A Division of General Dynamics Corp.
San Diego, Calif.

Automotive Division
J. J. RYAN
Pontiac Motor Division
General Motors Corp.
Pontiac, Mich.

Chemical Division
O. A. KRAL
Minnesota Mining &
Manufacturing Co.
St. Paul, Minn.

Electronic Division
GORDON BECKHART
Radio Corporation of America
Moorestown, N. J.

Textile & Needle Trades Division
R. E. HEILAND
Lehigh University
Bethlehem, Pa.

Industrial Quality Control is published monthly by the American Society for Quality Control, Inc. Entered as second-class matter on Sept. 18, 1950. Second-class postage paid at the post office at Milwaukee, Wis., and at additional mailing offices.

Industrial Quality Control is sent to all members of the Society as one of the privileges of membership. Subscriptions from non-members are not accepted. Subscriptions for members *only* are $3.00 of the annual membership dues. Subscriptions for company, public, and university libraries are: 1 yr.—$9.00; 2 yrs.—$17.00; 3 yrs.—$25.00; 5 yrs.—$40.00. Back issues of Vols. I-X are available at $6.00 per volume including index; Vol. XI, $9.00; XII-XV, $10.00 ea. Individual copies are $1.00 each. Microfilm editions by volume are also available. The cost per volume is: I-VII, $10.00; Vol. VIII, ff., $2.00 ea.

Orders for library subscriptions, back issues, and microfilm editions should be accompanied by remittance made payable to the American Society for Quality Control, Inc. *Orders under $3.00 must be accompanied by remittance.*

Industrial Quality Control is regularly indexed in the *APPLIED SCIENCE & TECHNOLOGY INDEX* published by The H. W. Wilson Company, 950 University Avenue, New York 52, N. Y.

Neither this magazine, nor any portion of it may be copied or otherwise reproduced without written permission of the copyright owner. Requests for copyright release should be addressed to the editor, Mason E. Wescott. The statements and opinions given in the articles and papers in *Industrial Quality Control* are the views of the authors and not necessarily those of the Society.

Notification of address change should be sent to the secretary of your section and to the Executive Secretary's office. Allow approximately seven weeks for the change to become effective.

Executive Secretary and Publications office: Rm. 6185 Plankinton Bldg., 161 West Wisconsin Avenue, Milwaukee 3, Wisconsin. Society's New York Address: Rm. 949B, 463 West St., New York 14, N.Y.

Address all correspondence to American Society for Quality Control, Inc., Rm. 6185 Plankinton Bldg., 161 West Wisconsin Avenue, Milwaukee 3, Wisconsin.

Copyright 1960
American Society for Quality Control, Inc.
Printed in U.S.A. All rights reserved

INDUSTRIAL QUALITY CONTROL

Vol. XVII, No. 3 September, 1960

ARTICLES

5 **Linear Contrasts, Part III**
CHESTER H. McCALL, JR. **523:00:000**
This series of articles presents four "popular" procedures for the detection of specific differences existing among a set of k-means in an analysis of variance study, together with a discussion of the merits of each procedure.

9 **Statistical Quality Control—The Cybernetic Approach to Business Operations**
MELVIN F. SHAKUN **100;600:20;30:400**
The author shows how the cybernetic cycle functions in the application of statistical quality control to business operations.

12 **Starting a Control Chart, The Effect of Number And Size of Samples on the Level of Significance at the Start of a Control Chart for Sample Means**
F. PROSCHAN and I. R. SAVAGE **111:70:000**
The authors observe that the recommendations as to the number of subgroups needed to initiate a control chart for $\bar{X}$ are not fully in agreement. In this article, they determine how the level of significance is affected by the number of samples used to calculate the control limits.

14 **Consolidated Rating System**
ELDEN E. JENSEN and JOHN K. HANE **340:80:000**
The authors have developed a system of comparison that incorporates both effectiveness and improvement. The article covers the development and application of the resultant rating equation.

19 **Modern Quality Control Pays Off in Woodwork**
ROBERT CHATEAUNEUF **100:70:424**
The organization of statistical quality control in a cabinet factory is traced, based on the principle of quality cost vs. production value.

26 **A Vendor Rating System for Material of Any Complexity**
LEONARD E. GRAY **351:40:400**
The author describes a vendor-rating system which was developed and which is being used by a medium sized company that produces small quantities of high-quality electronic and precision electro-mechanical equipments made to military specifications and rigid company requirements.

31 **Cost of Reliability**
BEN I. FUNK **800:10;30;40;60;70:419**
The author confronts the complex problem of how to budget for reliability in the hope that these comments might accelerate progress in reliability and, at the same time, help to keep costs within reason.

DEPARTMENTS

From the President's Desk, Another Step Forward 4
Book Reviews 34
What's New? 38
Section Briefs 46
Professional Development Note 49
Section Calendar 52
ASQC Announces 53
Positions Available 54
Product Education Service 54
Clinics, Conferences, and Courses 55
Consulting Services 56

EDITOR:

Mason E. Wescott

The Statistics Center
Rutgers • The State University
New Brunswick, N. J.

DEPARTMENT EDITORS:

W. D. Baten, Book Reviews
P. C. Clifford, T. A. Budne, Problems
Ellis R. Ott, Practical Aids
R. A. Wylie, What's New
J. M. Juran, Management's Corner
M. E. Wescott, Scrap Box
Paul A. Robert, Supervisor's Circle
Thomas M. Kearney, Section Briefs
D. S. Chambers, ASQC News

WEST COAST ADV. REP.

Whaley-Simpson Co.
6608 Selma Ave.
Los Angeles, Calif.
HOllywood 3-7157
700 Montgomery Bldg., Suite 305
San Francisco, Calif.

AMERICAN SOCIETY FOR QUALITY CONTROL, INC.

Managing Editor
George R. Foster

Administrative Secretary
William P. Youngclaus, Jr.

Office Manager
Jean Truettner

Room 6185, Plankinton Bldg. 161 West Wisconsin Avenue Milwaukee 3, Wisconsin

From the President's Desk

Another Step Forward

Perhaps readers of IQC may have noticed the fact that the July, 1960 — the No. 1 issue of Vol. XVII — carried 48 rather than the usual 40 pages to which it has been limited for the past several years. If so, the August issue, with 56 pages, must have been a *real* surprise!

This increase in page size in our journal is neither an accident nor a temporary bonus. As discussed in last month's editorial, it represents part of the planned expansion to better serve the Society's needs. The 56 page issues which began in August will continue regularly. Although current advertising income and the pro-rata share of dues income for publication costs do not yet fully underwrite the expense of this 16 page increase, the officers of the Society, meeting in San Francisco on May 26, recognized the urgency of providing more manuscript space in IQC and built into the budget for the next fiscal year provisions which will meet this increased publication cost.

As a result of this action, it will now be possible to reduce quickly to normal dimensions the heavy backlog of accepted papers still awaiting publication at the end of Vol. XVI. Further, assuming that the volume of submitted manuscripts does not increase sharply, this additional space in IQC should substantially shorten the unhealthy time-lag that has existed between final acceptance of a submitted paper and its eventual appearance in the journal.

With the availability of Technometrics, the companion journal to IQC published jointly by ASQC and ASA, and with this 40 percent increase in issue size for IQC, it should now be possible for the Society's journal to serve more effectively the total quality control function. However, this cannot be done by merely increasing the *size* of IQC. Character and quality must always be the criteria for acceptability of material for publication. But the spectrum of total quality control is a broad band, and it is imperative for the Society's journal to serve these expanding interests among its readers by providing both space and pertinency of content.

Our journal has a two-fold obligation to meet if it is to deserve recognition as the organ of a professional society: (1) it must carry enough content of recognized, professional, technical stature to support the Society's professed objectives *as* a professional society, and (2) it must constantly provide the *opportunity* for educational challenge in the sense of stimulating new interests on the part of its readers in both applied and theoretical directions.

The authorized increase in issue size for Vol. XVII is one important forward step in harmony with these objectives.

Jay McClure

LINEAR CONTRASTS

PART III

CHESTER H. McCALL, JR.

Booz-Allen Applied Research, Inc., Bethesda, Md.

IN PARTS I and II, linear contrasts were defined.* Also presented were orthogonal contrasts and techniques developed by Henry Scheffe, David Duncan, and John Tukey. In this part, a method due to efforts of Student[17], Newman[12], and Keuls[6], is presented; several other techniques and references are indicated; and, relative merits of the five procedures discussed in these articles are given.

The Method of Student-Newman-Keuls

Unlike the methods described thus far, this procedure has not been well publicized. Duncan[19] discusses a Newman - Keuls Sequential Range Test. Federer[3] attributes this contrast technique to all three men indicated above. The basic tables used for this process are given as Tables VI and VII in Part II of this series. Considerable work has been done[9,11,13,14] in developing and extending these tables. More accurate and detailed tables have been prepared under the direction of Leon Harter at Wright Air Development Center, Dayton, Ohio.[23,24] For the illustration which follows, we shall utilize only quantities, q_k from Table VI of Part II in this series.

The technique here is similar to that utilized in Duncan's test. The standard error of a single mean is computed in the usual way, namely,

$$S_{\bar{x}} = [\text{residual mean square} \div n]^{1/2} \quad (1)$$

One next computes a sequence of terms defined as

$$W_k = q_k S_{\bar{x}} \quad (2)$$

where k = the number of means in the given factor, and q_k is the appropriate term from Table VI in the column headed k and the row labeled with the degrees of freedom associated with the residual mean square in the analysis of variance table. The means are then ranked and a triangular table of differences set up. Comparisons for these differences are made with the appropriate W_k indicated in formula (2) above.

We can best illustrate this by utilizing some data given in Reference (16). The experiment was a randomized block design in which the effect of six

ASQC LCS Code 523:00:000

*Parts I and II were published in the July and August, 1960, issues of *Industrial Quality Control*.

treatments on the yield point of steel discs was studied. In addition, six ingots were examined under all treatments. The computed F for the ingot effects was 4.15 which (for 5 and 25 degrees of freedom) is significant at better than the 0.05 level. The residual mean square was 0.739. The first step is to compute the standard error of the mean from (1):

$$S_{\bar{x}} = [0.739 \div 6]^{1/2} = 0.35$$

Next, the means (in tons per square inch) are ranked:

Ingot	A	F	C	B	E	D
Mean	20.73	21.27	21.40	21.67	22.23	22.73

From (2) above we can compute W_2 through W_6. Using the q_k's from Table VI in Part II in the row

Table I—Student - Newman - Keuls Significant Ranges

k	q_k	W_k
2	2.92	1.025
3	3.53	1.239
4	3.90	1.369
5	4.17	1.464
6	4.37	1.534

with 25 degrees of freedom, we arrive at the values in Table I. Here a triangular table of differences is again set up. To indicate a different way to evaluate the significance of the ranges we shall use a method suggested by a referee. Table II, the table of differences, represents the differences between the ingot means indicated by the appropriate row and column letters.

The steps in detecting significant differences are as follows:

1. The two extremes, D and A are compared against W_6 from Table I. Since the difference 2.00 exceeds 1.534, D and A are declared significantly different.

2. The group of six means is now partitioned into two groups of five each. That is, A through E and F through D. These differences are compared with $W_5 = 1.464$. A and E are seen to be significantly different, D and F are not.

The set of five means from A through E is now partitioned into two groups of four means each; namely, A through B and F through E. These differences are compared to $W_4 = 1.369$. Neither is found to be significant.

4. After step three, no further subdivisions are necessary since only the pairs A, D and A, E are significantly different from each other. The process of detecting significance stops when the first subdivision of the set detects no further significance. The significant differences are starred in Table II.

Table II—Differences Among Ingot Means

Ingot	D	E	B	C	F
A	2.00*	1.50*	0.94	0.67	0.54
F	1.46	0.96	0.40	0.13	
C	1.33	0.83	0.27		
B	1.06	0.56			
E	0.50				

Table III summarizes those groups of means which have been declared homogeneous. Means not underlined by the same line are significantly different from each other.

Table III—Significant Ingot Differences in Steel Experiment

Ingot	A	F	C	B	E	D
Mean	20.73	21.27	21.40	21.67	22.23	22.73

A Comparison By Example

Before making statements regarding the five linear contrast techniques presented thus far, it seems appropriate to present an example in which the methods of Scheffe, Duncan, Tukey, and Student - Newman - Keuls are each utilized. In this way, the extent to which homogeneous groups of means vary will be evident.

The experiment analyzed here is taken from Reference (4). The weighing and packaging of a finished product in a factory is carried out by six machines. The product is supposedly packed in sacks of 50 kilograms each. A control sack is selected periodically from each machine. The variation in weight from the expected 50 kgs is of interest. The observations are in units of 0.1 kilograms and are measured in departures from 50 kgs.

The analysis of variance on machine means yielded a computed F of 11.6. At 5 and 75 degrees of freedom this is obviously significant at better than the 0.01 level. The residual mean square, based upon 75 degrees of freedom, was 3.49. The standard error of a single machine mean is seen to be

$$S_{\bar{x}} = \{3.49 \div 16\}^{1/2} = 0.467$$

since each machine mean was based on 16 observations. The standard error is necessary for all tests which follow.

Before proceeding, the machine means ranked are:

Machine	5	1	4	6	2	3
Mean	0.000	0.375	0.938	2.000	2.750	4.188

Table IV indicates the pair-wise difference between all means. It is these differences which are compared to the necessary terms from each of the four methods.

The Scheffe process requires the computation of

$$A = \{(k - 1)F\}^{1/2}$$
$$= \{5 \times 3.27\}^{1/2} = 4.044$$

where k represents the number of means and the F value is taken from the table at the 0.01 level for 5 and 75 degrees of freedom (recall that the table F, against which the computed F is compared, is the appropriate quantity for this formula).

To declare pair-wise significance, the mean differences must exceed

$$\sqrt{2}\, A\, S_{\bar{x}} = 1.414 \times 4.044 \times 0.467$$
$$= 2.67$$

Only those differences, in Table IV, which exceed 2.67 are declared significant using Scheffe's contrast procedure. Table VII indicates which groups of means are homogeneous according to Scheffe's process.

Table IV—Differences Between Machine Means

Machine	3	2	6	4	1
5	4.188	2.750	2.000	0.938	0.375
1	3.813	2.375	1.625	0.563	
4	3.250	1.812	1.062		
6	2.188	.750			
2	1.438				

To obtain shortest significant differences using Duncan's multiple range test, we set up Table V. Recall that k indicates the number of means in the

Table V—Shortest Significant Ranges by Duncan's Procedure

k	r_k	R_k
2	3.75	1.75
3	3.91	1.83
4	4.02	1.88
5	4.11	1.92
6	4.16	1.94

range of means being compared; r_k is the approximate term from Table I of Part II for the given values of k and the associated degrees of freedom for the residual mean square; and, $R_k = r_k S_{\bar{x}}$.

The appropriate R_k values in Table V are then compared to the mean differences indicated in Table IV. All differences for $k = 4, 5, 6$ are significant. For $k = 2$, all differences are non-significant. For $k = 3$, only 3 and 6 differ significantly. The others are non-significant. Table VII indicates the homogeneous groups by this technique.

To obtain the Student-Newman-Keuls significant ranges, Table VI is set up. The k indicates the number of means in the range being compared; q_k is the appropriate term from Table VII of Part II in the column headed k and the row labeled with the degrees of freedom associated with the residual mean square in the ANOVA table; and $W_k = q_k S_{\bar{x}}$.

The mean differences in Table IV are now compared to the appropriate terms in Table VI. It is

Table VI—Student - Newman - Keuls Significant Ranges

k	q_k	W_k
2	3.75	1.75
3	4.27	1.99
4	4.59	2.14
5	4.81	2.25
6	4.98	2.33

seen that a non-significant difference first occurs for $k = 4$. Table VII indicates which groups are homogeneous using this technique.

Tukey's use of the Studentized range calls for pair-wise differences to exceed 2.33 (W_6 in Table VI) for significance to occur.

Rather than list the significant means, as indicated by the four methods, homogeneous groupings are underlined in Table VII. The means not underlined by a single line are declared significantly different for all methods.

Careful study of Table VII should indicate definite differences in the methods. If one compares Duncan and Scheffe on this set of data, Duncan gives more significant differences; i.e., 3 and 6, 2 and 1, 6 and 5.

Table VII—Homogeneous Machine Means

Machine	5	1	4	6	2	3
Mean	0.000	0.375	0.938	2.000	2.750	4.188
Method						
Scheffe						
Tukey						
Student-Newman-Keuls						
Duncan						

As a matter of fact, Tukey has one more significance than Scheffe; Student - Newman - Keuls yields one more than Tukey; and, Duncan indicates one more than Student-Newman-Keuls. These obvious differences should be of some concern to the practitioner who wonders which technique should be used. The following section, therefore, compares the methods.

Some Comments

In this section, each technique discussed in this series is evaluated in a fashion which the author hopes will allow the practitioner to select that technique most appropriate to his needs. Excellent comparisons among these procedures are given in (3) (7) (18) (1) (20).* The concensus of opinion seems to be that it is highly desirable not to indicate homogeneity when a real difference exists. Further, any technique employed should be fairly simple. (Duncan's Multiple Comparison test was omitted from this series due to its complexity when compared to those presented).

In experiments involving only two means, the least significant difference (the standard use of the "t" test) is appropriate. Further, as indicated in (7), in experiments involving more than two means the L.S.D. procedure is applicable only to randomly selected or predetermined pairs of means identified in the objectives of the experiment. It is advisable not to use the L.S.D. unless a significant F has been obtained.

Pearson and Hartley (13) and (14) have shown that the Type I error, where the extremes from a set of k means are being compared, is not α, but increases as k increases. For five samples, where $\alpha = 0.05$ for two means, $\alpha = 0.27$; for 20 samples, $\alpha = 0.86$. The L.S.D. test obviously is dangerous here.

If orthogonal contrasts are employed, care must be exercised to select the set of contrasts of interest *prior to* the conduct of the experiment. If this is done, each contrast can be validly tested for significance. However, since many experiments are probing in nature, it is often impossible to select the contrasts in advance of the study.

Under the above conditions, utilizing the procedure of Henry Scheffe, it is possible to test any and all contrasts a posteriori. This is the only one which allows for unequal size samples. Further, Scheffe has indicated that when comparing more than two means, Tukey's method is increasingly inefficient as k gets larger. On the other hand, Scheffe states that where two means are compared and samples are of the same size, Tukey's method should be used in preference to his. This supports the contention that when comparisons between two means dominates interpretations in a study, Scheffe's procedure is least desired.

In the case of Duncan's Multiple Range Test there is a better Type II protection than in the other techniques. On the other hand, there will be more Type I errors. It has not yet been established (7) whether one must have a significant F to use this test.

It is interesting to note here that Tukey (20) feels that, where heterogeneity of variances is suspected or a serious departure from normality indicated, a method based on the F-distribution is to be preferred over a Studentized range. Tukey's procedure is certainly more conservative than Duncan's or Student-Newman-Keuls. It is (19) uniformly less powerful

*See also sections 3.4, 3.5, 3.6, and 3.7 in *The Analysis of Variance*, by Henry Scheffe, John Wiley & Sons, Inc., New York, N.Y., 1959.

than these tests. On the other hand, it has simplicity and does have a smaller Type I error than Duncan or Student-Newman-Keuls.

The Student-Newman-Keuls method seems to have many desirable properties. In (22) there is a strong indication of a preference for this over all other methods.

In the preceding paragraphs, indications have been given of differences among the techniques. As a final summary, one way we can classify the tests is into three groups: pair-wise tests, where samples are the same size; pair-wise tests, where samples are of differing sizes; and, contrasts among any number of means.

In the first case, the probability of committing at least one Type I error among the $k(k-1)/2$ pair-wise differences, if the null hypotheses are all true, is α for Tukey's technique and that of Student-Newman-Keuls. For the L.S.D. test, α increases with increased k, while for Duncan's multiple range test, α increases but considerably less than for the L.S.D.

In the second case indicated above, Scheffe's procedure has a smaller Type I error than the L.S.D. as k increases.

For the case of contrasts among a number of means, the probability of a Type I error on at least one contrast when all null hypotheses are true, is α for Scheffe's procedure.

The author suggests to the practitioner that careful attention be paid to all points in this series of articles. Experience, guided by the limitations and advantages pointed out previously, is perhaps the best answer. Certainly no one has yet solved this problem in a closed sense. In selecting estimators, one must consider carefully the type of estimate desired and the associated advantages and disadvantages. This is also true in using linear contrast procedures.

Some Further Contributions

The works of Student, Pearson, Duncan, Tukey, and Scheffe have contributed to advances in the important area of linear contrasts. The techniques selected for this series were used because of their wide acceptance, ease, and applicability. Other outstanding papers of interest (5) (8) (9) (10) (11) (15) (19) (21) and (22) should be consulted for those who desire more detailed discussions.

Summary

In linear contrast procedures, we find a key to the problem of isolating those differences which are significant in an experiment. Having found a key, one must honestly confess that this key will open many doors. Which door is selected becomes a most important choice. We are here confronted with considerations of power, size of samples, types of comparisons, and normality of errors — to name a few. But, at least now, we have a choice. The decision rests with the user.

References

1. Duncan, D., "Multiple Range and Multiple F Tests," *Biometrics*, Volume 11, No. 1, March, 1955.
2. Duncan, D. B., "On the Properties of Multiple Comparisons Test," *Virginia Journal of Science*, Volume 3, No. 1, January, 1952.
3. Federer, Walter T., *Experimental Design*, The Macmillan Co., New York, 1955.
4. Hald, A., *Statistical Theory with Engineering Applications*, John Wiley and Sons, Inc., New York, p. 76, 1952.
5. Halperin, M., Greenhouse, S., Cornfield, J., and Zalokav, J., "Tables and Percentage Points for the Studentized Maximum Absolute Deviate in Normal Samples," *Journal of the American Statistical Association*, Volume 50, 185-195, March, 1955.
6. Keuls, M., "The Use of the Studentized Range in Connection with an Analysis of Variance," *Euphytica* 1, 112-122, 1952.
7. LeClerg, E., "Mean Separation by the Functional Analysis of Variance and Multiple Comparisons," Agricultural Research Service, U.S.D.A., May, 1957.
8. Link, R. F., and Wallace, D. L., "Some Short Cuts to Allowances," Ditto, Princeton University, March, 1952.
9. May, Joyce M., "Extended and Corrected Tables of the Upper Percentage Points of the 'Studentized' Range," *Biometrika*, 39, 192-195, 1952.
10. Nair, K. R., "The Studentized form of the Extreme mean Square Test in the Analysis of Variance," *Biometrika*, 35, 16-31, 1948.
11. Nair, K. R., "Tables of Percentage Points of the 'Studentized' Extreme Deviate from the Sample Mean," *Biometrika*, 39, 189-191, 1952.
12. Newman, D., "The Distribution of Range in Samples from a Normal Population, Expressed in Terms of an Independent Estimate of Standard Deviation," *Biometrika*, 31:20-30, 1939.
13. Pearson, E. S., "The Probability Integral of the Range in Samples of n Observations from a Normal Population," *Biometrika*, 32:301-310, 1942.
14. Pearson, E. S., and Hartley, H. O., "Tables of the Probability Integral of the Studentized Range," *Biometrika*, 33:89-99, 1943.
15. Pillai, K. C. S., "On the Distribution of 'Studentized' Range," *Biometrika*, 39, 194-195, 1952.
16. Rosander, A. C., *Elementary Principles of Statistics*, D. Van Nostrand Co., Inc., New York, 1951.
17. Student, "Errors of Routine Analysis," *Biometrika*, 19:151-164, 1927.
18. Thomas, Raymond E., *On Linear Contrasts and the Analysis of Variance*, Masters' Thesis, the George Washington University, 1957.
19. Thompson, W. R., "On a Criterion for the Rejection of Observations and the Distribution of the Ratio of Deviation to Sampling Standard Deviation," *Annals of Mathematical Statistics*, 6:214-219, 1935.
20. Tukey, John, "Comparing Individual Means in the Analysis of Variance," *Biometrics*, Volume 5, No. 2, June, 1949.
21. Tukey, John, "The Problem of Multiple Comparisons," Unpublished dittoed notes, Princeton University, 1953.
22. "Simultaneous Significance Tests for Multiple Contrasts in the Analysis of Variance," Unpublished Mimeographed Notes, Purdue University, 1959.
23. Harter, H. L., and Clemm, D. S., "The Probability Integrals of the Range and of the Studentized Range. Probability Integral, Percentage Points, and Moments of the Range," WADC Technical Report 58-484, Vol. 1, April, 1959.
24. Harter, H. L., Clemm, D. S., and Guthrie, E. H., "The Probability Integrals of the Range and of the Studentized Range. Probability Integral and Percentage Points of the Studentized Range; Critical Values for Duncan's New Multiple Range Test," WADC Technical Report 58-484, Vol. II, October, 1959.

STATISTICAL

QUALITY CONTROL

The Cybernetic Approach To Business Operations

In the Animal and in the Machine

MELVIN F. SHAKUN, *Price Waterhouse & Co., New York, N. Y.*

Here is something to watch—a champion negotiating the fall line with perfect parallel technique. He is skiing *in control.*

You observe an automobile moving down a straight highway. It does not maintain an exactly straight path, but wanders slightly to the left and to the right, the driver correcting with the steering wheel as required. For a time the car remains within the limits of the road — it is *in control.* Then, suddenly, it veers off the road — something has made it go "out of control."

" . . . and now remains
That we find out the cause of this effect,
Or rather say, the cause of this defect,
For this effect defective comes by cause;"
Hamlet, Act II, Scene 2

These intuitive examples are illustrative of *control,* a subject with which man has always been concerned, but which in recent years has assumed unprecedented significance.

Control appears in many forms. In cybernetics, which deals with "control and communication in the animal and the machine," there is the control of the electrical engineer and the neurophysiologist (how to control a guided missile; what control mechanism functions when a person reaches for a pencil). In budgetary control, there is the control of business operations by the executive achieved by "comparison or measurement of actual performance against predetermined plans and objectives."[1] In statistical quality control, there is the control of manufacturing processes—and more recently of certain administrative and clerical operations—by the industrial engineer.

In all of these forms, control may be viewed as cybernetic—as a continuing, corrective process wherein actual performance is compared with stated objectives, and the variation or error is used to take corrective action.

Such a process is known as *feedback* control, which may be viewed as a three-step (cybernetic) cycle:

1. **Specification of goals** or objectives stemming from value judgments and influenced by feedback from Step 3.
2. **Operation** in pursuit of the goals through execution of a course of action selected in Step 3.
3. **Evaluation** of performance resulting in respecification of goals and reselection of a course of action for further operation.

Let us see how this cybernetic cycle functions in the application of statistical quality control to business operations. W. A. Shewhart, in seeking ways to control the quality of manufactured products, recognized the parallel between the three-step control cycle given above and the manufacturing sequence consisting of:

1. **Specification** of what is wanted in a manufactured product.
2. **Production** of the product.
3. **Inspection** of the product to see if the engineering specification is satisfied.

He recognized that a sequence of parts could not be manufactured "exactly" alike — that while they might be "nearly alike," there would always be some slight differences due to inherent chance (random) causes in the production process. Such small variations are not significant if they are not detrimental to the functioning of the part. Moreover, if such variations are stable we can *predict* that the quality characteristic of virtually all of the *future* product will be within determinable limits.

Thus, the state of statistical control as described by Shewhart[2] represents an ideal goal wherein there is predictability and minimum variability of quality. In order to achieve this state, Shewhart suggested the use of *control charts.* These control charts are characterized by a central line drawn at the average value of the variable being charted, and two control limits placed at a certain distance (usually two or three standard deviations) on either side

ASQC LCS Codes 100;600:20;30:400

of the central line. If the plotted points fall nicely within the control limits we may judge that the process is "in control." Indeed, the process should be left alone since it is behaving as well as one can expect. (Further refinement in this case is usually only possible by a major change in the productive process with accompanying dollar expenditures.)

On the other hand, the falling of points outside the control limits (or other evidence such as a heavy run of points on one side of the central line) represents a significant deviation — a warning signal that a foreign or assignable cause has entered the process resulting in a change in the cause system. In this case corrective action should be taken on the process which is "out of control" in order to eliminate such assignable causes. Thus, statistical control charts provide criteria for distinguishing between variation which is natural or inherent in the process and variation which is the result of outside forces. Otherwise put, the criteria aid in deciding whether to leave a process alone (in-control or stable condition) and when to take corrective action (out-of-control condition).

There are various forms of control charts. These fall into two broad categories, *variables* and *attributes*. Charts for variables, while more sensitive than those for attributes, require that an actual numerical measurement be taken, whereas those for attributes merely require the designation of an item as conforming or nonconforming.

A simple experiment will clearly reveal the principles of attributes inspection. Fill a bowl with a large number of beads, say 10,000, a small percentage of which, say 12 percent, are red representing defectives, and a large percentage, 88 percent, of which are white representing nondefectives. Using a sampling paddle, mix the beads thoroughly and withdraw a sample of 100. Count the number of defectives, red beads, and compute the fraction defective as the number of reds divided by 100, the total number drawn. Return the sample to the bowl. Repeat the procedure for 50 such samples of 100 each.

The 50 values of fraction defective so obtained may be plotted on a control chart using procedures

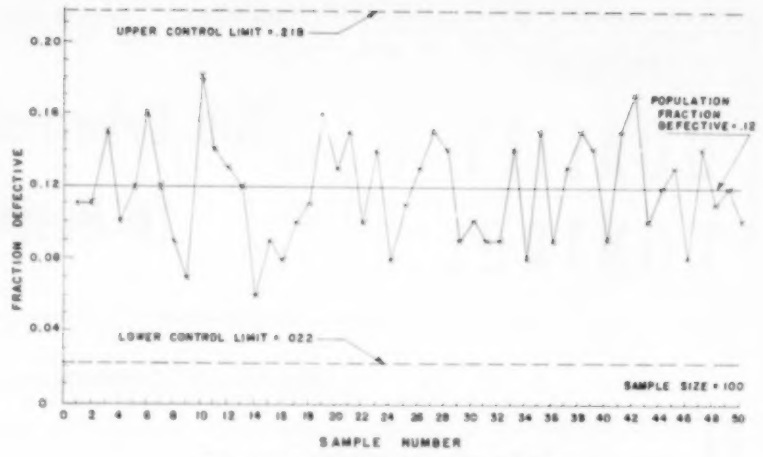


Figure 1 — Control Chart for Fraction Defective

given in Reference (3) for computing three standard deviation upper and lower control limits. Typical results are given in Figure 1. Since the points all fall nicely within control[1] limits, we may consider the selection process to be random, i.e., in control. There are apparently no assignable causes of variation present.

In order to apply these concepts to a clerical operation, we may think of the red beads as representing clerical errors. A control

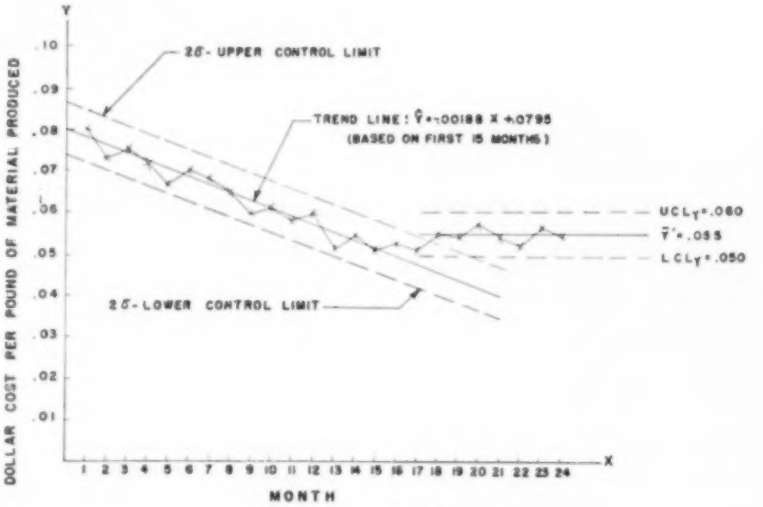

2σ - UPPER CONTROL LIMIT
TREND LINE: Ŷ = -.00188 X + .0795
(BASED ON FIRST 15 MONTHS)
UCL_Y = .080
Ȳ = .065
LCL_Y = .050
2σ - LOWER CONTROL LIMIT
DOLLAR COST PER POUND OF MATERIAL PRODUCED
MONTH

Figure 2 — Control Chart for Cost Per Pound

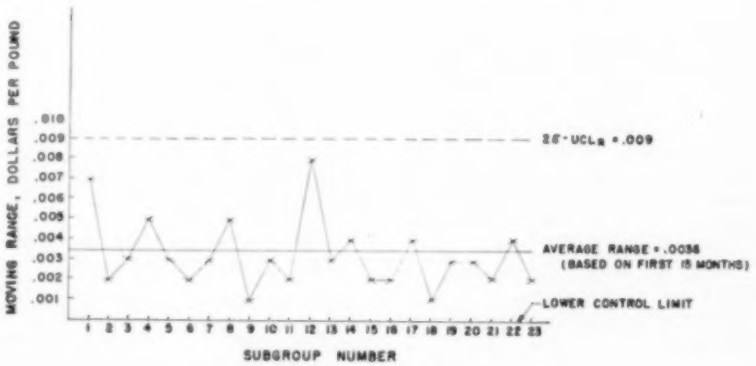

2σ - UCL_R = .009
AVERAGE RANGE = .0036
(BASED ON FIRST 15 MONTHS)
LOWER CONTROL LIMIT
MOVING RANGE, DOLLARS PER POUND
SUBGROUP NUMBER

Figure 3 — Control Chart for Moving Range

chart for such a clerical operation will exhibit points within control limits if errors are occuring in a stable random fashion. If points fall outside limits (or the average error fraction is too high), attempts should be made to improve quality by eliminating assignable causes. These are discoverable through careful study of the clerical operation. Frequently a relatively small percentage of clerks are responsible for most of the errors.

In addition to attributes, control charts for *variables* may be used to detect changes in the universe. As an illustration consider the following manufacturing cost data:

Month	Dollar cost/lb	Moving range
1	0.080	
2	0.073	0.007
3	0.075	0.002
4	0.072	0.003
5	0.067	0.005
6	0.070	0.003
7	0.068	0.002
8	0.065	0.003
9	0.060	0.005
10	0.061	0.001
11	0.058	0.003
12	0.060	0.002
13	0.052	0.008
14	0.055	0.003
15	0.051	0.004
16	0.053	0.002
17	0.051	0.002
18	0.055	0.004
19	0.054	0.001
20	0.057	0.003
21	0.054	0.003
22	0.052	0.002
23	0.056	0.004
24	0.054	0.002

The data gives the manufacturing cost per pound over a two-year period. The column of moving ranges is obtained as the difference between successive pairs of cost per pound data. The downward trend in cost per pound is a result of a cost reduction program, but this trend must level off somewhere. Management would like to detect this leveling as soon as it occurs. The control chart is useful in this regard.

Using the method of least squares together with two standard deviation control limits (see Reference (3) for technical details), control charts for cost per pound and moving range are plotted in Figures 2 and 3 based on data for the first fifteen months. Since points for the first fifteen months fall within control limits on both charts, we may consider a trend having a stable random variation to be in operation, and may project the control limits into the future. When this is done, the control chart for cost per pound detects the first sign of the leveling of the trend by the falling of the eighteenth point above the upper control limit. Management is thus altered. Verification is afforded by subsequent points falling outside limits on the cost per pound chart. On the moving range chart the points remain within control limits indicating that while the trend has leveled off the inherent random variation remains stable. Apparently the full benefits of the present cost reduction program have now been felt. Until such time as additional cost reduction steps are undertaken, stabilization of the cost per pound at about the $0.055 level is desirable. Control charts based on data beginning with the eighteenth month should be useful in this regard. This gives an $R = 0.003$ for computing control limits.

There are numerous opportunities in industrial practice for fruitful application of statistical control techniques. These cover many areas of business management — personnel, budgetary control, clerical work, cost analysis, sales forecasting, manufacturing and accident control, to mention several. They stem from an increasing requirement for *control* in business operations. In response to this need, statistical quality control brings a practical philosophy of approach. This involves a feedback comparison of results and objectives in an attempt to achieve a desirable state of predictable operation. The control chart plays a central role, for it detects those deviations which are indeed significant in an endless pattern of statistical fluctuation. Such significant deviations result from assignable causes "for this effect defective comes by cause." By guiding us to corrective action, the control chart may serve as a powerful ally in our efforts to bring about a desired state of control, which is to say, an achievement of worthwhile goals. As such, it is worthy of our understanding.

References

1. G. A. Welsch, *Budgeting: Profit-Planning and Control*, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957
2. W. A. Shewhart, *Statistical Method from the Viewpoint of Quality Control*, Washington: The Graduate School, Department of Agriculture, 1939
3. E. L. Grant, *Statistical Quality Control*, McGraw-Hill Book Co., 1952

ATTENTION:

Quality Control Engineers!

If you are a Quality Control Engineer or Statistical Analyst, you'll be interested in the new career opportunities at Remington Rand Univac.

There's a fresh enthusiasm in the activity at Univac, and the opportunity for personal progress and satisfaction has never been greater. We refer to it as Univac's *Atmosphere of Achievement* ... an excellent environment in which you can enjoy greater professional advancement.

Demanding programs of ultra-reliability have placed an unprecedented importance on the Univac Quality Assurance Engineer because of his vital role in meeting reliability requirements.

If you are interested in your professional advancement, are thinking of changing positions, or would consider a change, be sure to investigate these opportunities which are now available.

QUALITY CONTROL ENGINEERS

To develop and apply statistical quality control techniques, initiate and evaluate test and inspection procedures for the manufacture of superior quality products.

RELIABILITY ENGINEERS

To perform reliability analysis and predictions, develop failure reporting procedures, analyze failures and recommend corrective action.

Openings are at several levels of responsibility. Engineering or Science degree required, with a minimum of 2 years experience in electronics or related fields.

Salaries commensurate with experience. Company-paid relocation costs, liberal employee benefits.

R. K. PATTERSON, Department A-9

Remington Rand Univac

DIVISION OF SPERRY RAND CORPORATION
2750 West Seventh Street, St. Paul 16, Minnesota

STARTING A CONTROL CHART

The Effect of Number And Size of Samples On the Level of Significance At the Start of a Control Chart for Sample Means

F. Proschan and I. R. Savage†*

Introduction

In starting a control chart to detect a shift in a normal population mean, we may be fortunate enough to know the population mean $\overline{X}'$ and the population standard deviation σ'. In this case, if we use control limits $\overline{X}' \pm 3\,\sigma'_{\overline{x}}$, then the level of significance (the risk of a point falling outside of limits even though the process mean has not shifted) is 0.0027. However, in the usual case, we do not know $\overline{X}'$ or $\sigma'_{\overline{x}}$, but must estimate them from past data.

Various texts on quality control discuss the number of samples needed to initiate a control chart. For example, we find:

"On statistical grounds, it is desirable that control limits be based on at least 25 subgroups.

". . . However, where subgroups are obtained slowly there is a natural desire on the part of those who initiated the control charts to draw some conclusions from them within a reasonable time. This impatience for an answer frequently leads to the policy of making preliminary calculations of control limits from the first 8 or 10 subgroups, with subsequent modifications of limits as more subgroups are obtained." (Reference 4, pp. 136-137)

"In order to get a reasonably accurate preliminary picture of a process, material, or laboratory technique, we usually try to get at least 20 samples, preferably 25, each consisting of four or five measurements. Occasionally, where measurements are very expensive, as in determining the velocity of penetration of armor plate, as few as eight samples, of four measurements each, may be used as the initial data." (2, p. 112)

"It is not necessary that a process be in a state of statistical control before a control chart is used to control the process. Trial limits may be based on as few as ten samples of four items each . . ." (3, p. 238)

"The determination of the minimum number of subgroups is a compromise between obtaining the guidance of the control chart as quickly as possible, and the desire for the guidance to be reliable. Usually, at least 25 subgroups should be chosen." (1, p. 787)

Clearly, the recommendations as to the number of subgroups needed to initiate a control chart for $\overline{X}$ are not fully in agreement, and, in general, are not supported by a quantitative analysis demonstrating the reason for the recommendation. Evidently, there is a need for a quantitative analysis of the effect of starting a control chart with any given number of samples. In this article we determine how the level of significance is affected by the number of samples used to calculate the control limits. It is well to keep in mind, however, that this is but one consideration in determining the number of sample points needed to initiate the control chart. Other considerations are:

(a) At first, ". . . the mere act of taking and recording measurements is sometimes responsible for a change in the pattern of variation." (4, p. 136)

(b) If too few points are taken in computing the control limits originally, lack of control in the process may not be detected, and unduly liberal control limits may be set up. (See (5) for an analysis of the operating characteristic of the control chart for sample means.)

Nevertheless, we feel that it would be helpful to know quantitatively how the level of significance is

ASQC LCS Code 111:70:000
*Sylvania Electric Products Inc., Mountain View, Calif.
†University of Minnesota, Minneapolis, Minn.

Table I—Largest Number, m, of Subgroups for which $\alpha > 0.01$ for Sample Sizes n, when the Control Chart for Means is Based on the Range

n	m
2	15
3	9
4	7
5	6
6	5
7	5
8	4
9	4
10	-
12	4
14	4
16	3
18	3
20	3

In each case above, $\alpha < 0.02$

Table II—Largest Number, m, of Subgroups for which $\alpha > 0.01$ for Sample Sizes n, when the Control Chart for Means is Based on the Standard Deviation

n	m
2	16
3	9
4	7
5	6
6	5
7	5
8	4
9	4
10	4
12	4
14	3
16	3
18	3
20	3

In each case above, $\alpha < 0.02$

Table III—Largest Number, m, of Subgroups for which $\alpha > 0.005$ for Sample Sizes n, when the Control Chart for Means is Based on the Standard Deviation

n	m
2	42
3	25
4	18
5	16
6	14
7	13
8	12
9	11
10	11
12	10
14	9
16	9
18	9
20	8

affected by the number, m, and the size, n, of subgroups used to set the limits.

Summary of Results Using Range

To be precise, we shall consider the following model. We suppose that

(a) a process has been, and is, in a state of control,

(b) measurements on individual units from the process are normally and independently distributed, and

(c) three-sigma control limits for a chart for means have been calculated by using *each* of the first m samples of n units. None of the first m sample points have been eliminated in computing control limits, even if one or more lies outside of limits.

What is the largest value of m for which $\alpha > 0.01$, where α is the probability that the mean of the next sample taken from the process still in control will fall outside of control limits? Note that α may be considered the level of significance of the test of the hypothesis that the process mean has not shifted.

For various sample sizes n, the largest number of subgroups m for which the significance level α exceeds 0.01 is given in Table I.

Derivation

$\overline{X}_i$ = mean of i^{th} sample

$\overline{\overline{X}}$ = mean of X_i $(i = 1, 2, \ldots, m)$

n = common sample size

$\overline{R}$ = average of the m sample ranges

d_2 = expected value of the range in samples of n, randomly selected from a normal population of unit standard deviation

m = number of samples available at the start of the control chart

$$u = \left| \frac{\overline{X}_{m+1} - \overline{\overline{X}}}{\frac{\overline{R}}{d_2}\sqrt{\frac{1}{n} + \frac{1}{mn}}} \right|$$

Control limits are customarily set at $\overline{\overline{X}}' \pm 3\,\sigma'_{\overline{X}}$. Suppose $\overline{\overline{X}}'$ and σ' are unknown so that the control limits are set at

$$\overline{\overline{X}} \pm 3\left(\frac{\overline{R}}{d_2\sqrt{n}}\right) \qquad (1)$$

The probability, α, of the next sample mean, $\overline{X}_{m+1}$, falling outside of the control limits is given by

$$\alpha = \text{Prob.}\left(|\,\overline{X}_{m+1} - \overline{\overline{X}}\,| > 3\,\frac{\overline{R}}{d_2\sqrt{n}}\right), \qquad (2)$$

so that

$$\alpha = \text{Prob.}\left(u > 3\sqrt{\frac{m}{m+1}}\right) \qquad (3)$$

Bounds for α may be determined by the use of Tables 3, 4, 5, 6, 7, 8 of (6, pp. 63-65), which give respectively the 90, 95, 98, 99, 99.8, and 99.9 percentiles of u. By using Table 6 of (6), which gives the 99 percentile of u, for a given value of n the largest value of m was determined such that $\alpha > 0.01$. (See Table I) Six-point Lagrangian interpolation was performed to determine the 99 percentile value of u for $n = 2$, $m = 16$ and four-point Lagrangian interpolation for the 99 percentile of u for $n = 4$, $m = 7$. In addition, by using Table 5 of (6) it was established that α was actually less than 0.02 for the combinations of m and n given in Table I.

Using Sample Standard Deviation Instead of Range

With only a small amount of data available at the start of a control chart for means, it might be considered advisable to replace the mean range by a more efficient estimate obtained by pooling the sample variances. The control limits would then be established as

$$\overline{\overline{X}} \pm 3\,\frac{\sigma}{\sqrt{n}} \qquad (4)$$

where

$$\sigma = \sqrt{\sum_{i=1}^{m} \sigma_i^2/m}$$

and σ_i^2 = variance of i^{th} sample.

If this more efficient procedure for estimating the population standard deviation is followed, will the level of significance of the control chart for means come out closer to the desired value, 0.0027? Or, putting it another way, will there be any decrease in the maximum number of subgroups, for which α, the level of significance, exceeds 0.01?

In general, the answer is no, as shown by Table II, which was obtained by an elementary application of the Student-t statistic. Table II gives the largest value of m for a given value of n such that $\alpha > 0.01$, using (4) as the control limits.

Note that Table II differs from Table I in only 2 cases: $n = 2$, 14. In both cases, m differs in the two tables by 1 only. Hence, in general, control limits established by (4) are not noticeably superior to those of (1) (using as the criterion of superiority, the maximum number of subgroups for which $\alpha > 0.01$).

For purposes of reference, we include Table III.

References

1. Bowker and Lieberman, *Handbook of Industrial Statistics,* Prentice-Hall, Inc., 1955.
2. Burr, Irving W., *Engineering Statistics and Quality Control,* McGraw-Hill, 1953.
3. Cowden, Dudley J., *Statistical Methods in Quality Control,* Prentice-Hall, 1957.
4. Grant, Eugene L., *Statistical Quality Control,* McGraw-Hill, 1952.
5. King, Edgar P., "The Operating Characteristics of the Control Chart for Sample Means," *The Annals of Mathematical Statistics,* September 1952. Vol. 23, No. 3, pp. 384-395.
6. Lord, E., "The Use of Range in Place of Standard Deviation in the t-test," *Biometrika,* Vol. 34, Parts 1, 2 (1947), pp. 41-67.

CONSOLIDATED RATING SYSTEM

ELDEN E. JENSEN and JOHN K. HANE

Introduction

ALMOST any operating business whether large or small, at some time has to compare various companies, departments, operations or individuals one against the other. Some of the comparisons are based entirely on effectiveness or performance while others are concerned only with the degree of improvement in performance by the unit being rated. Many times it would be desirable to have some system of comparison whereby both effectiveness and improvement could be incorporated. Facing the need for a system combining effectiveness and improvement, the authors developed such a method. The section that follows is a discussion of the development and application of the resultant rating equation. Also included in an additional section is a discussion of the design and construction of a nomograph or alignment chart, which can be used to simplify the calculations required by the mathematical model designed to bring into the rating system factors of efficiency and improvement.

Development of the Rating Equation

Before the advent of the rating equation, individual items within a department were graded percentagewise as the number of items actually produced versus the number of items that had been scheduled. These computations resulted in a percent effectiveness for that item for the designated period of time. This scoring could then be accomplished in the same way on a department level, number of items actually produced versus the number of items that were scheduled to be produced. The period of time used to produce an effectiveness score is optional and dependent only upon particular management functions.

This departmental score could then be compared with other departmental scores, provided the departments were doing similar type work, to produce a ranking based on effectiveness. Likewise then, the weekly, monthly, or yearly departmental score could be compared with historical data to determine the degree of improvement or regression.* The improvement of the individual departments could be compared one against the other and a ranking of departments by degree of improvement could be accomplished.

Bear in mind at this point, however, that these are only simple examples of general methods for ranking individual units on *either* effectiveness *or* improvement. There are many deviations from the two brief systems cited, and these have been presented only as a means of clarifying what is meant by effectiveness score and/or improvement rank.

Assume now that some method is presently in operation whereby a weekly or monthly effectiveness score can be computed for a group of individual departments. With this information available, the mathematical model developed to incorporate effectiveness and improvement can be applied. The equation is as follows:

ASQC LCS Code 340:80:000

Mr. Hane is a first lieutenant and Mr. Jensen is a civilian employee with the Directorate, Supply and Transportation, Hill AFB, Utah.

*The word "regression" as used in this article means the opposite of "improvement", and has no connection with the statistical meaning of regression as used in correlation and regression analysis.

$$x = \sqrt{a^2 \pm k\,b^2} \qquad (1)$$

where: x = score, including credit for effectiveness and improvement, to be used for ranking purposes
a = effectiveness score for designated period of time, for example, one month
b = improvement or regression of effectiveness score as compared to a moving average of effectiveness scores for the previous three rating periods
$\pm$ = addition operation if comparison of effectiveness scores shows improvement; negative operation if regression
k = factor to introduce added credit for improvement. (This factor can be varied according to specific needs.)

It should be noted at this point that the factor k can be varied according to the degree of improvement desired in the final score used for ranking purposes. For example, if the factor was one, practically no credit at all would be given for improvement. If the effectiveness score was of the order of 80 and the improvement around six the result would be a final score of 80.22 which adds only 0.22 for improvement in performance. On the other hand, if the factor k is increased to ten, the equation may become useless for all practical purposes. If one department experiences a bad month and its effectiveness drops to 60 percent as compared to a moving average of 79, using the factor ten in the equation makes the final score, x, imaginary!

The final score x will always have a real value as long as $\sqrt{k} < (a/b)$. So if it is possible to make an estimate of the minimum value a/b likely to be met in practice, a ceiling can be set on the factor k that may be used. Thus, in the second example given, $a/b = 60/19$, so $k < (60/19)^2 = 9.97$. Hence a $k = 9$ could be used, but not $k = 10$.

After considerable experimentation to determine the most desirable factor, five was selected as the optimum for our particular system. However, as was stated previously, this is not a set factor but can be varied (within limits), depending on the emphasis one desires to place on the improvement in effectiveness.

It is not possible to say exactly what percentage of the final score is composed of effectiveness or improvement as the final score is determined on a sliding scale, such that, as improvement increases, it will make up a larger percentage of the final score. For some indication as to the degree that the rating equation using $k = 5$ emphasizes effectiveness in relation to improvement, a correlation study was performed which ranked 15 similar departments for one month by improvement, effectiveness, and by the rating equation scores. Correlation coefficients were computed by the rank-difference method using the Spearman Rank Correlation equation.[2] The following correlations resulted:

a. Effectiveness rank versus rating equation rank—Rank Correlation = 0.943
b. Improvement rank versus rating equation rank—Rank Correlation = 0.536

This suggests that the rating equation using $k = 5$ places more emphasis on effectiveness than it does on improvement, since a correlation of 1.0 is considered perfect. For our specific needs, a system was required that would place the majority of the weight in ranking on effectiveness, but yet give some bonus for having shown improvement over the preceding rating periods. Using an improvement factor of $k = 5$ in the rating equation gave the desired result as the correlation study indicates. However, to place additional emphasis on improvement, the factor k can be adjusted to a maximum, as was previously discussed, as long as $k < (a/b)^2$.

In determining the amount of improvement or regression, it is believed that a comparison of the current effectiveness figure with a moving average of previous effectiveness scores will prove most accurate. Again, experimentation was performed to determine the number of previous scores considered to be optimum if incorporated into a moving average. It was concluded that the average of the three most recent scoring periods reacted most favorably as a moving average to be used for means of comparison. From this comparison of past effectiveness scores versus the present effectiveness score, the degree of improvement or regression is determined.

The data in Table I are presented as examples of the use of the rating equation (Equation 1).

The computations for the rating score equation, $x = \sqrt{a^2 \pm kb^2}$, can be eliminated with the use of a nomograph or alignment chart. A discussion of the design and construction of a nomograph follows in the next section.

Construction of a 3-Variable Nomograph

Alignment charts, or nomographs, present a means of solving equations graphically. The main advantages to be offered by their use are simplicity and speed, which are complemented with accuracy. Nomographs can be constructed to solve graphically equations containing three, four, five or more variables.[3]

The equation discussed in the preceding pages is of the three-variable type, the variables being final score, improvement, and effectiveness. The following paragraphs will be devoted to the development of basic equations needed for the construction of a nomograph for the rating equation.

When a nomograph is constructed from a three-variable equation such as $x = a + b$, three parallel scales should be drawn so that a straight line constructed between two points on the outer scales, will

Table I—Data Used for Illustration of Rating Equation, Using $k = 5$

Dept. Number	3-month Moving Average	Monthly Effectiveness Score = a	Rank	Improvement or Regression = b	Rank	Proposed Score From Equation = x	Rank
1	89	81	7	−8	9	79.0	8
2	83	84	5	1	4	84.0	5
3	81	80	8	−1	5	80.0	7
4	91	88	2	−3	7	87.7	3
5	89	86	3	−3	7	85.7	4
6	78	82	6	4	3	82.5	6
7	82	89	1	7	2	90.4	1
8	77	76	9	−1	5	75.9	9
9	75	85	4	10	1	87.9	2

intersect the middle scale at a point equal to the algebraic sum of the variables on the outer scales.[1] In the development of the proof on which construction of a nomograph is based, the following fundamental equation will be used:

$$X = A + B \qquad (2)$$

The first step is to write the equations of the three scales:

$$S_a = m_1 a$$

$$S_b = m_2 b$$

$$S_x = m_3 x$$

where S_a, S_b, or S_x = any distance from the origin of the scale to any designated value a, b, or x

a, b, or x = any designated value on the respective scales

m_1, m_2, or m_3 = modulus of each scale.

The second step in the proof is to draw three lines of arbitrary length parallel to each other with their origins on the same straight line designated ORIGIN on Fig. 1. Algebraically, using equation (2) as an example, if B equals 0, then A = X. If a straight line is drawn from A = a to B = 0, Fig. 1, the line will intersect the S_x scale at a point X = x. Since the equation defines A = X when B = 0, the moduli of the S_a and S_x scales must be so related that the reading at the point x is identical to the reading at the point a. Through the use of plane geometry, a relationship can be set up between the moduli of the scales and the perpendicular distances between the scales, P and Q. By similar triangles, the distance m_3x is to the distance Q as the distance m_1a is to the distance (P + Q), Fig. 1.

$$\frac{m_3 x}{Q} = \frac{m_1 a}{(P+Q)} \qquad (3)$$

Since it was previously stated that a = x, equation (2) can be transformed to the following:

$$\frac{m_3}{Q} = \frac{m_1}{(P+Q)}$$

$$m_3 = \frac{m_1 Q}{(P+Q)} \qquad (4)$$

In the third step of the proof, if one looks at the original equation X = A + B, it can be seen that X = B if A = 0. A straight line is then constructed from A = 0 to B = b through the point X = x. Again, since the equation defines X = B when A = 0, the moduli of the S_x and S_b scales must be so related that the b reading has the same value as the x. Also, by similar triangles (Fig. 1), the distance m_3x is to the distance P as the distance m_2b is to the distance (P + Q).

$$\frac{m_3 x}{P} = \frac{m_2 b}{(P+Q)} \qquad (5)$$

Since the x and b points have the same value, equation (4) becomes

$$m_3 = \frac{m_2 p}{(P+Q)} \qquad (6)$$

Combining equations (4) and (6) yields the ratio of distance between the scales compared to the moduli of the scales.

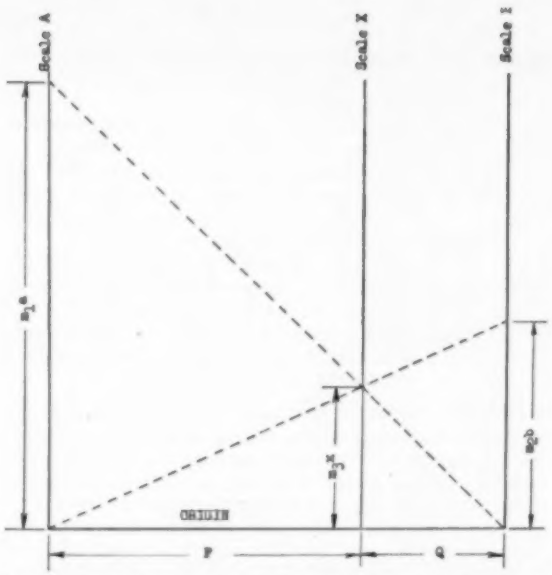


Figure 1—Basic Nomograph Plan, Illustrating Relation Between Scale Moduli and Distances

$$m_3 = \frac{m_1 Q}{(P+Q)} \qquad (4)$$

$$m_3 = \frac{m_2 P}{(P+Q)} \qquad (6)$$

$$\frac{m_1 Q}{(P+Q)} = \frac{m_2 P}{(P+Q)}$$

$$\frac{m_1}{m_2} = \frac{P}{Q} \qquad (7)$$

Substituting equation (7) into equation (4) yields a relationship between the moduli of the three scales:

$$m_3 = \frac{m_1 Q}{\frac{m_1 Q}{m_2} + Q} \qquad (7) \text{ and } (4)$$

$$m_3 = \frac{m_1 Q}{Q\left(\frac{m_1}{m_2} + 1\right)}$$

$$m_3 = \frac{m_1 m_2}{m_1 + m_2} \qquad (8)$$

This concludes the derivation of the two basic equations (7) and (8), which are necessary for the construction of a three-variable, parallel-line alignment chart.

Construction of the Rating Equation Nomograph

By applying equations (7) and (8) to the rating equation developed in the preceding text, $x = \sqrt{a^2 \pm 5b^2}$, a nomograph can be constructed to eliminate the laborious calculations necessary to solve repeatedly the three-variable equation. Such a chart can often be complicated and difficult to construct, but if it is to be used continually the labor concerned with making it can be justified. As was previously explained, the plus sign under the radical is used when the monthly effectiveness score is an improvement, the minus sign when the score is a

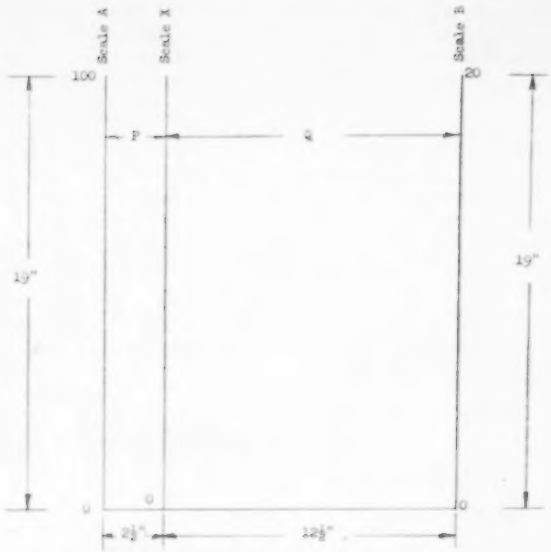


Figure 2—Skeleton of Proposed Nomograph for Rating Equation

regression. The plus sign or improvement score will be used in the following explanation of construction. The negative sign will be treated in a later paragraph. The first step in the process of designing the nomograph is the simplification of the equation by squaring both sides,

$$x^2 = a^2 + 5b^2 \qquad (9)$$

Before any calculations are made, several things must be decided, either by facts or assumption. For example, the variable a, effectiveness score, must range from 0 to 100. The variable b, improvement, could also range from 0 to 100, but for all practical purposes a range of 0 to 20 could be assumed. Establishing the limits on two variables defines the limits of the third value, x, from 0 to approximately 110. The second thing that must be decided is the size of the proposed chart. Let it be assumed that the maximum desired height of the scales is 19 inches, and

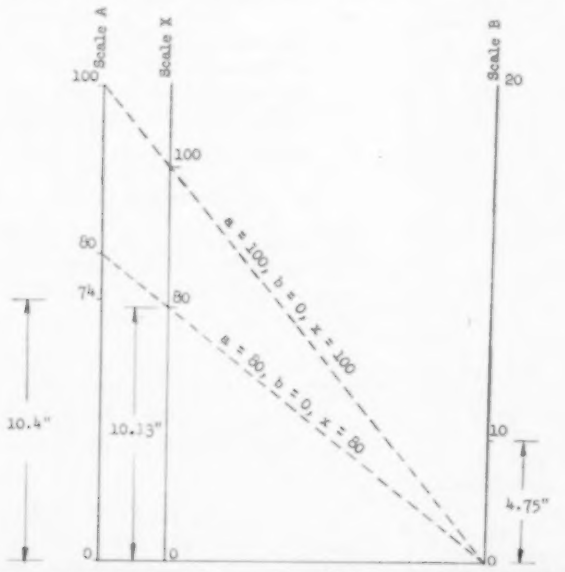


Figure 3—Illustration of Increments Applied in Proper Measured Positions

the maximum width between the two outer scales is 15 inches. This relatively large size allows for more accuracy of construction than could be obtained on a smaller chart. If a more convenient size is desired, reduction could be accomplished by having the chart reproduced to a smaller size. Now that the scale limits and linear size have been defined, steps can be taken to calculate the moduli of the three scales. The equations of the scales must first be written.

$$\text{Scale A } S_a = m_1 a^2$$
$$\text{Scale B } S_b = m_2 5b^2$$
$$\text{Scale X } S_x = m_3 x^2$$

S_a, S_b, or S_x being the linear distance from the origin to any point a, b, or x on the scale.
After writing the equations for the scales, the moduli can be calculated.

For scale A:
$$S_a = m_1 a^2$$
$$19'' = m_1 (100)^2$$
$$19'' = (m_1)\ (10{,}000)$$
$$m_1 = 0.0019$$

For scale B:
$$S_b = m_2 5b^2$$
$$19'' = (m_2)(5)(20)^2$$
$$19'' = (m_2)(5)(400)$$
$$m_2 = 0.0095$$

From equation (8)
$$m_3 = \frac{m_1 m_2}{m_1 + m_2}$$
$$m_3 = \frac{(0.0019)\quad(0.0095)}{(0.0019) + (0.0095)}$$
$$m_3 = 0.001583$$

Having calculated the moduli for the three scales, the position of the middle or x scale relative to the two outer scales, must now be determined. Using equation (7) and knowing that $(P + Q)$, Fig. 1, has been defined as 15 inches, the following can be accomplished:

$$\frac{P}{Q} = \frac{m_1}{m_2}$$
$$P = \frac{m_1 Q}{m_2}$$
$$P = \frac{0.0019\ Q}{0.0095}$$
$$P = 0.2Q$$
$$P + Q = 15 \text{ inches}$$

Since $P = 0.2Q$ then

$$0.2Q + Q = 15 \text{ inches}$$
$$1.2Q = 15 \text{ inches}$$
$$Q = 12.5 \text{ inches}$$
$$P + Q = 15 \text{ inches}$$
$$P + 12.5 = 15 \text{ inches}$$
$$P = 2.5 \text{ inches}$$

The skeleton of the chart has now been determined as is illustrated in Fig. 2. Examination of the rating equation $x^2 = a^2 + 5b^2$ reveals that if two of the variables are equal to zero, the third must also equal zero. Therefore, the zero point of each scale will be on the same horizontal line. This line is called the origin. The graduations on each of the three scales can be determined by multiplying the modulus of the scale times the desired quantity to arrive at the

distance from the origin to the specific quantity. For example:

To determine the position of the value 74 on the S_a scale:

$$S_{74} = (m_1)(a)^2$$
$$S_{74} = (0.0019)(74)^2$$
$$S_{74} = 10.40 \text{ inches from origin.}$$

To determine the position of the value 10 on the S_b scale:

$$S_{10} = m_2 5 b^2$$
$$S_{10} = (0.0095)(5)(10)^2$$
$$S_{10} = 4.75 \text{ inches from origin.}$$

To determine the position of the value 80 on the S_x scale:

$$S_{80} = m_3 x^2$$
$$S_{80} = (0.001583)(80)^2$$
$$S_{80} = 10.13 \text{ inches from origin.}$$

Similarly, sufficient calculations can be made to complete the graduations on each of the three scales. These calculated points can be checked for validity by drawing a straight line from 0 on the S_b scale to any desired point on the S_a scale. If the graduations are accurate, the constructed line will intersect the S_a and S_x scales at identical values, because if 0 is substituted in the equation for b, then x must equal a. See Fig. 3.

To simplify the construction of the regression scale the quickest method is to invert the improvement scale and label it Regression. Now an alternate scale, "Final Score if Regression" can be determined by constructing straight lines from various points on the effectiveness scale to the 0 point on the Regression scale. The point where this line intersects the "Final Score if Regression" axis will have the same value as the effectiveness score since there was no regression or improvement. The entire scale can be determined in this manner. This nomograph constructed for the rating equation including effectiveness, improvement, and regression is illustrated in Fig. 4.

An actual example will now be solved using the rating equation and also the graphic method which is illustrated in Fig. 4.

Monthly effectiveness score
$$a = 85$$

3-Month moving average $= 75$

Improvement
$$b = 10$$
$$X = \sqrt{a^2 \pm 5b^2}$$
$$X = \sqrt{(85)^2 + (5)(10)^2}$$
$$X = \sqrt{7225 + 500}$$
$$X = \sqrt{7725}$$
$$X = 87.9$$

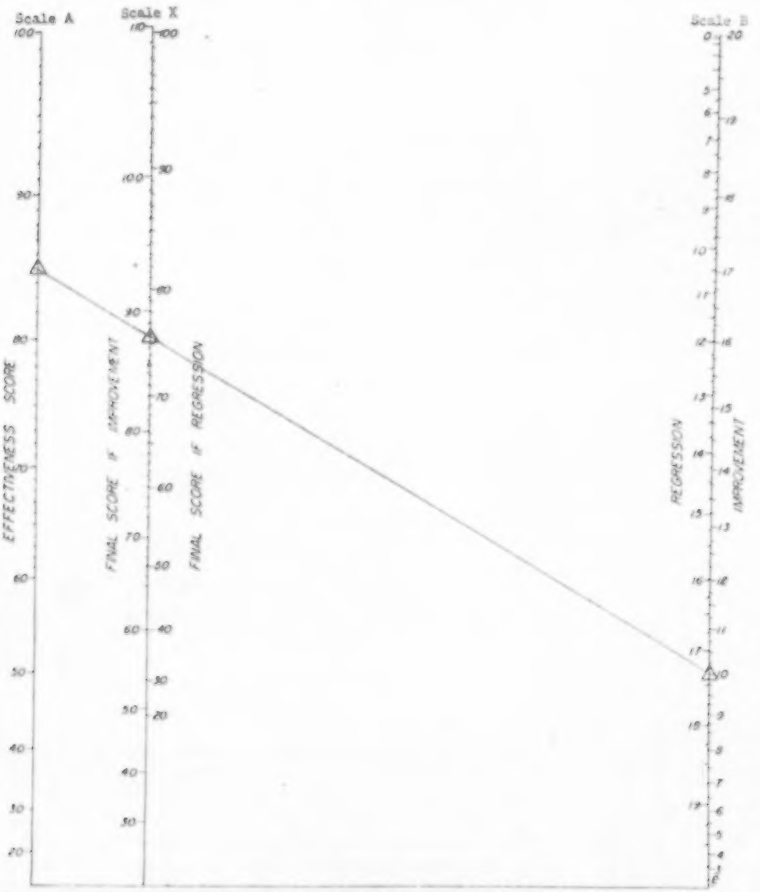


Figure 4—Alignment Chart Showing Relationship Between Effectiveness Score, Improvement, Regression, and Final Score

To obtain the solution using the nomograph in Fig. 4, the following steps are recommended:

1. Make a point on the "Effectiveness Score" axis at 85 = a
2. Make a point on the "Improvement" axis at 10 = b.
3. Construct a straight line to connect the two points, Effectiveness = 85 and Improvement = 10.
4. The answer or X can be read at the point of intersection of the constructed line and the "Final Score if Improvement" axis.

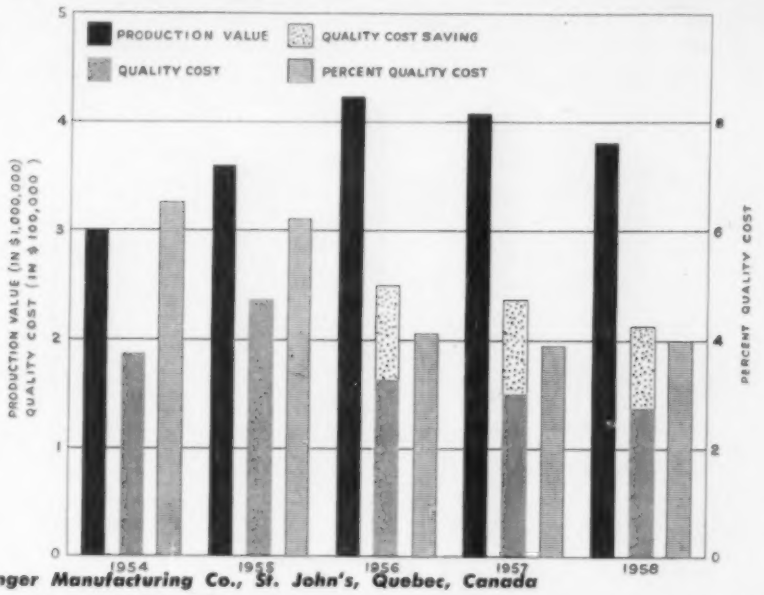
References

1. Luzadder, W. J., *Graphics for Engineers,* Prentice-Hall, Inc., Englewood Cliffs, N.J. First Edition, 1957.

2. McCarthy, Philip J., *Introduction to Statistical Reasoning,* p. 382. McGraw-Hill Book Co., Inc., New York, N.Y., First Edition, 1957.

3. Perry, John H., *Chemical Engineer's Handbook,* pp. 100-105. McGraw-Hill Book Co., Inc., New York, N.Y. Third Edition, 1950.

Modern QC PAYS OFF In Woodwork



ROBERT CHATEAUNEUF *The Singer Manufacturing Co., St. John's, Quebec, Canada*

Abstract

The organization of statistical quality control in a cabinet factory is traced, based on the principle of quality cost vs. production value. A plant-wide quality-consciousness was created first. Quantity of inspection was replaced by an emphasis on superior quality. Control charts were used and performance reported at all levels, with resulting savings.

Introduction

Building and maintaining quality is a growing problem. Day by day, products and processes become more complex, profit margins narrower. At the same time, specifications become more demanding. A final inspection may maintain the quality reputation of a product, but it does nothing to reduce excessive inspection, waste and scrap losses, or make more effective the use of the personnel and equipment involved. The introduction of the Singer quality control program in Canada began in 1955, included the adoption of statistical quality control techniques in the factory, and is largely responsible for higher quality at less cost. The following factors have contributed most to the success of the quality control program, and will be discussed in this paper:

1. The determination of the quality cost in dollars.
2. Creation of a plant-wide quality atmosphere.
3. Samples establishing quality standard limits.
4. Reduction and replacement of 100 percent inspection by sampling.
5. Daily quality evaluation of the finished goods produced.
6. The use of statistical quality control charts.
7. Quality performance reports to all levels of management.

ASQC LCS Code 100:70:424

Determination of Quality Cost in Dollars

The quality cost is the ratio of the money spent for maintaining the quality against the cost value of the merchandise produced.

The quality cost is found by adding the following factors:

1. Departmental inspection and repair cost (daywork and piecework).
2. The value of rejects scrapped at last operation performed.
3. Centralized inspection and laboratory operating cost.
4. Fixed charges for individuals attached to quality, such as holidays, benefit and retirement plan, unemployment insurance and bonus.

The tabulation of the aforementioned factors should be as precise and complete as possible. The quality cost figures will reveal the seriousness of the situation. They will also indicate in which area it is most urgent to start quality control. Finally, quality cost figures will be a measure of the progress attained as experience develops.

What has been the performance at the Singer St. Johns Factory for recent years? In 1954, 6.5 cents were spent to maintain the quality for every dollar of woodwork goods produced. This percent is the ratio of the quality cost to the production value. In 1955, production had increased but the quality cost moved almost parallel to the production value. Quality Control was introduced at the end of 1955, and 12 to 14 months later another pattern had developed. Quality cost no longer moved parallel to the production value. The 6.5 cents and 6.2 cents spent for every dollar of production dropped to 4.1 cents, representing a saving of $56,000.00 over the quality cost of 1955. Comparing the present quality cost with the customary parallel move with the 1956, 1957 and 1958 production value would represent an appreciable yearly saving of $90,000.00 to $100,000.00. This saving is not detrimental to quality, which was maintained and improved. (Fig. 1)

Besides the yearly chart shown in Fig. 1, each department has its own Quality Cost Chart. These charts are plotted monthly and are circulated (book form) from top management to each production department head for his observation and initial.

The larger part of the savings are usually made during the first years. Then the big job is to keep quality cost low and quality level high.

Creation of a Quality Atmosphere

In the factory, top management was sold on statistical quality control but the production group was not. Therefore, the latter group

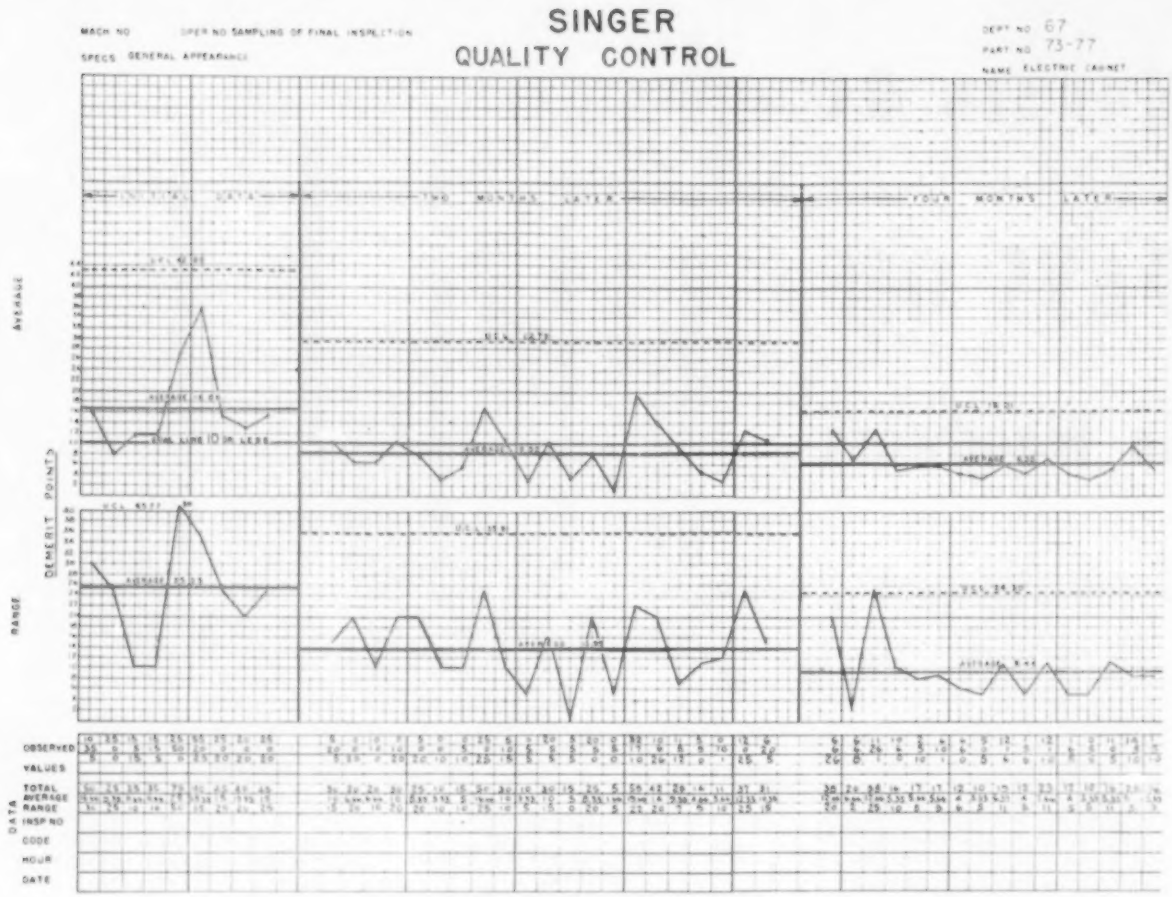


Figure 2—Three Quality Performance Pictures

THE SINGER MANUFACTURING COMPANY
ST. JOHN'S WORKS
QUALITY DEVIATION REPORT
TO DEPT. MANAGER
DEPT. NO 64
NUMBER OF TIME REPORTED
DATE 8/21/57
TIME 8:15 A.M.
M/C NO 1247
OPERATION NO
PART NAME & NO. 100245 - TABLE FLAP FOR SET #76 AND #92
DESCRIPTION OF DEVIATION 3/8" HOLES FOR H/C, STOP BRACKET NOT PROPERLY LOCATED.
REMARKS OR SUGGESTIONS SPECIAL ATTACHMENT ON JIG NOT PROPERLY SEATED.
QUALITY CONTROL DEPARTMENT
BY
COPIES TO WORKS MANAGER
SUPERINTENDENT
OTHER PERSONS CONCERNED.

Figure 3

was approached with selling ideas. The program was launched by a kick-off meeting that grouped all department managers, their assistants and foremen. A film on quality control was presented. The Works Manager emphasized the importance of reducing quality cost without lowering quality.

Tests have shown that visual 100 percent inspection made by humans has only 80 to 90 percent accuracy and does not give the necessary protection.

Quality control is based on the three major factors, the three M's . . . Man, Machine, and Material. It is important to reach the operators and the machine setter as well as the material handler.

Direct quality control meetings with the operators (15 to 30 minutes in a group of 10 to 15 operators) were very effective. Pocket pencil holders with a slogan printed thereon, "Our Quality is Our Security", were given to the employees.

The factory monthly paper and

posters were found to be valuable tools in promoting quality atmosphere.

Define the Quality Standards

It is indispensable to define quality standard with typical samples. It was observed that operators doing a similar job have individual quality concepts. It pays dividends if operators know exactly what is good, what can be repaired economically, and what is not acceptable.

Cabinet making, which deals with a non-homogeneous material such as wood, will require more appearance standards than furniture made with laminated decorative facing. Wood-grain imitation is made within an acceptable variation pattern. Plain wood has an unlimited decorative pattern which characterizes its distinction. To get such a distinction, the matching range should be in ratio with the retail price of the furniture. A nice color match range is difficult to obtain.

In the factory, samples were accumulated and submitted to the top and production management, to have them draw reasonable limits of acceptability. This limit depends a great deal on the part location and the class of cabinet.

These factors are directly connected to the quality cost figures. Operators like to have samples of acceptability at their operation. Such standard samples also help the newcomer to adjust quickly to acceptable quality standards.

Reduction and Replacement of 100 Percent Inspection by Sampling

Traditional 100 percent inspection is recognized to be expensive and inaccurate. It is expensive because it absorbs more labor and more gages. Quality is not something that is inspected. Quality is built into the product by the man, the material, and the machine. When thought of, along this line, inspection becomes a verification of the quality performance only and can be done by sampling. If the verification is done 100 percent, the operator's responsibility, which is to produce good work, is removed from him.

Responsibility for quality rests on the operators. For operations such as touch-up (minor repairs), it was found important to have the operator identify his work with a letter punch. On small pieces, to make sure that good parts are not thrown away, a special container identifies the

SUMMARY OF QUALITY CONTROL ACTIVITIES FOR WEEK ENDING: _____ DEPT NO. _____

NUMBER OF OBSERVATIONS INCLUDING PLOTTING OF CHARTS: 62 QUALITY CONTROLLED: H. RAYMOND

QUALITY DEVIATION

PART NO. & NAMES	TYPE OF DEFECTS	REPAIR %	SCRAP %	REMARKS
[illegible]	[illegible]	.008		[illegible]

QUALITY PERFORMANCE

PART NO. & NAMES	OPERATIONS STUDIED	PROCESS AVERAGE	THIS WEEK AVERAGE	LAST WEEK AVERAGE	REMARKS
C.T.S. PARTS	APPEARANCE AFTER 100 % INSP.	1.11	1.00	1.33	DEFECTS PER UNIT
CABINET #15	" " " "	5.40	3.00	2.66	" " "
CABINET #350	" " " "	2.44	1.11	3.33	" " "
CABINET #71 & #77	" " " "	3.05	3.66	2.66	" " "
CABINET #84 & #350	" " " "	2.04	1.33	3.33	" " "
ELECTRIC SETS	LACQUER AND REPAIR	21.23	14.3	20.	
C.T.S. CLOSED CASES	STATISTICAL SAMPLING INSP. AFTER 100% INSPECTION.	2.	1.5	2.3	DEFECTS PER UNIT
C.T.S. CENTER DRAWER	STATISTICAL SAMPLING INSP. REPLACING 100% INSP.	3.19	2.	3.	X CHART (FOR 2 OPERATORS).

COPIES TO: MESSRS. R. BALL
D. MERCIER
J.E. HEBERT
H. ROBIN
H. RAYMOND

Figure 4—Weekly Summary Report

work with the operator and makes it possible to sample the stock thrown in the scrap and pin-point the extremists.

Inspection by Sampling

A sampling inspection program for the incoming stock was organized with a sister factory that supplied all the semi-finished stock, such as veneer panels and so forth. Each wood-work shipment has a pallet of representative samples of the entire shipment. The sampling plan is tolerating up to 4 percent defective parts. Any item exceeding the desired quality level of 4 percent is inspected 100 percent. The surplus of defective material is then credited to the St. Johns Factory.

Findings of the inspection are entered on a special form and sent to the supplier to make necessary correction.

In the wood machining department, there was a visual 100 percent inspection for 50 items. These inspections, which kept two inspectors busy, were replaced by a roving inspector who verifies the quality of the work at its source. This is process quality control.

Operators themselves remove the obviously bad parts, and the assemblers do not assemble defective parts that are beyond repair. A complete sampling is done

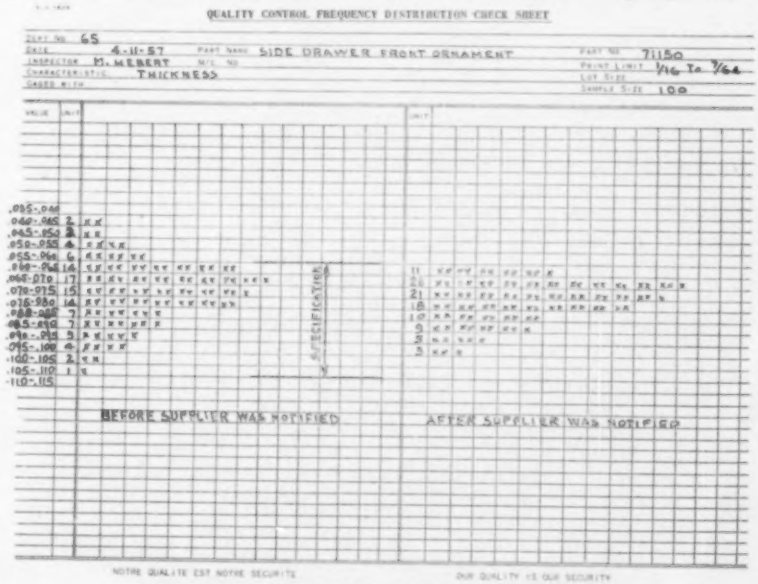


Figure 5—Two Patterns Before and After Vendor Notification

S. J. 1426

PROCESS QUALITY CONTROL CHART

PART NO. & NAME 100941 - LEAF COVER OPERATION NO AFTER POLISHING MACHINE NO _____ DEPT NO 64

OPERATOR CHECK # 64-21 MACHINE SETTER N. BESSETTE QUALITY CONTROLLER H. ROY

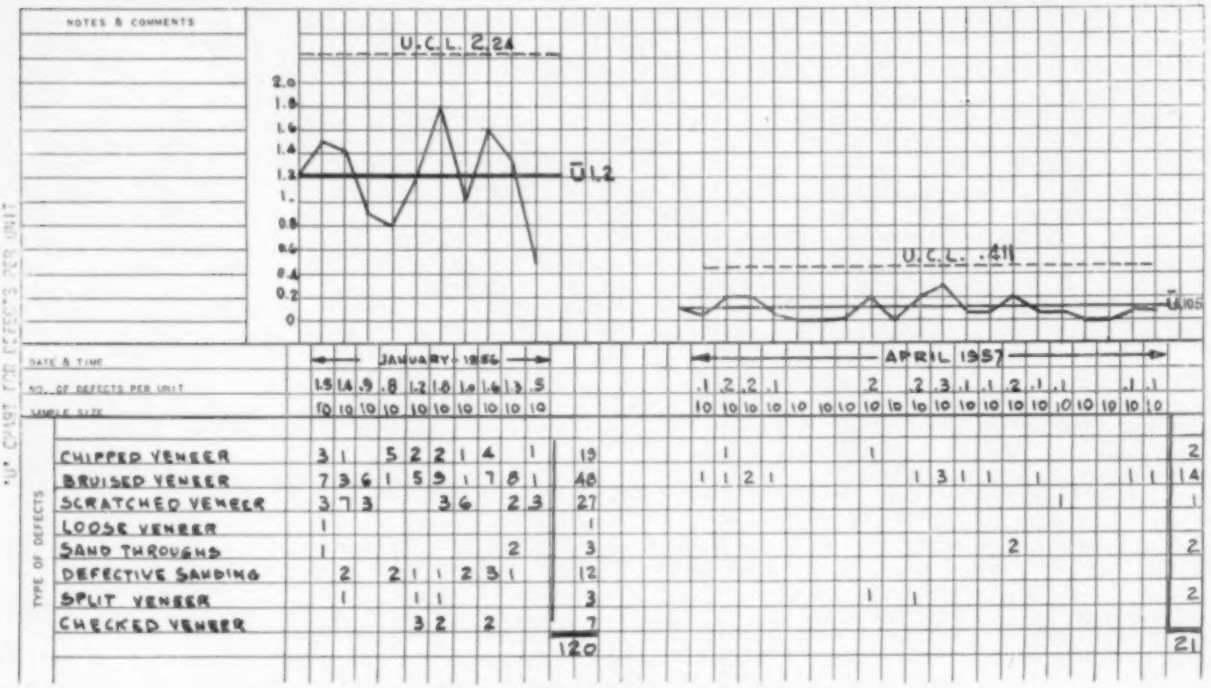

NOTES & COMMENTS
U.C.L. 2.24
2.0
1.8
1.6
1.4
1.2
1.
0.8
0.6
0.4
0.2
0
$\bar{U}$1.2
U.C.L. .411
$\bar{U}$.105
"U" COUNT FOR DEFECTS PER UNIT
DATE & TIME
JANUARY 1956
APRIL 1957
NO. OF DEFECTS PER UNIT
1.5 1.4 .9 .8 1.2 1.8 1.0 1.6 1.3 .5 .1 .2 .2 .1 2 .2 .3 .1 .1 .2 .1 .1 .1 .1
SAMPLE SIZE
10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10
TYPE OF DEFECTS
CHIPPED VENEER 3 1 5 2 2 1 4 1 19 1 1 2
BRUISED VENEER 7 3 6 1 5 9 1 7 8 1 48 1 1 2 1 1 3 1 1 1 1 1 14
SCRATCHED VENEER 3 7 3 3 6 2 3 27 1
LOOSE VENEER 1 1
SAND THROUGHS 1 2 3 2 2
DEFECTIVE SANDING 2 2 1 1 2 3 1 12
SPLIT VENEER 1 1 1 3 1 1 2
CHECKED VENEER 3 2 2 7
120 21

Figure 6—U Chart Used on Sewing Machine Cabinet Covers After Polishing Operation

S. J. 1431

PROCESS QUALITY CONTROL "P" CHART

PART NO. & NAME # 100942 - M/c PLATFORM OPERATION NO FLAP HINGE CUT MACHINE NO _____ DEPT NO 64

MACHINE OPERATOR CHECK # 64-12 MACHINE SETTER N. BESSETTE QUALITY CONTROLLER H. ROY

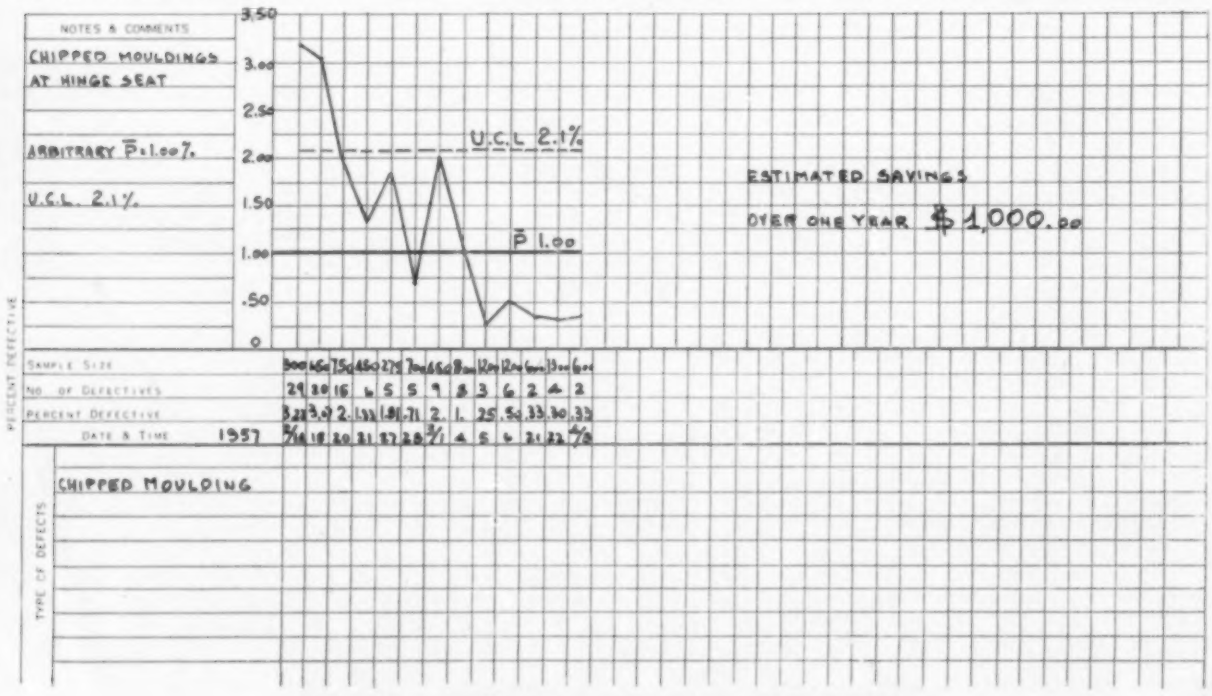

NOTES & COMMENTS
CHIPPED MOULDINGS AT HINGE SEAT
ARBITRARY $\bar{P}$=1.00%
U.C.L. 2.1%
3.50
3.00
2.50
2.00
1.50
1.00
.50
0
U.C.L. 2.1%
$\bar{P}$ 1.00
ESTIMATED SAVINGS
OVER ONE YEAR $1,000.00
PERCENT DEFECTIVE
SAMPLE SIZE 300 450 750 450 275 700 450 300 1200 1200 600 1350 600
NO. OF DEFECTIVES 29 30 16 6 5 5 9 8 3 6 2 4 2
PERCENT DEFECTIVE 9.2 3.0 2. 1.33 1.81 .71 2. 1. .25 .5 .33 .30 .33
DATE & TIME 1957 3/14 18 20 21 27 28 3/1 4 5 6 21 22 4/8
TYPE OF DEFECTS
CHIPPED MOULDING

Figure 7—P Chart Shows Improvement in Quality of Hinge Seat Cut

on the stock leaving a department. If the lot has an excess of defectives, it is sorted out and the labor is charged against the department at fault.

As a result, with a greater production, the value of material rejected was reduced by $28,000.00 in 1956. Likewise, an economy of $12,000.00 on woodwork inspection was realized. This was achieved by eliminating unnecessary 100 percent piecework inspection and a few daywork inspectors.

Daily Quality Evaluation of the Finished Goods Produced

One-hundred percent inspection on all individual items does not build in the quality. However, this type of 100 percent inspection has to be used for general appearance on finished products.

The story on this particular type of 100 percent inspection is amusing.

In 1955, two inspectors were doing a fairly good job but because they were not catching everything two other inspectors were doing a second 100 percent inspection before the packing. In the drive to reduce the factory quality cost, the two inspectors in the shipping department were removed and replaced by a statistical quality control sampling in the assembly department.

After the final 100 percent inspection, a sample size of three cabinets of each type is selected at random, inspected and rated daily with the following demerit points system:

Incidental
—Faults that will not cause failure in service, decrease life or necessitate additional servicing, such as very light bruise — 1 Demerit.

Minor
—Faults on appearance and workmanship that make product less desirable—5 Demerits.

Major
—Faults which will decrease life or require excessive servicing, such as touch-up by retailer. The customer will be dissatisfied with the purchase — 20 Demerits.

Critical
—Faults which may cause injury or damage. The customer will refuse to buy the product—50 Demerits.

The quality of a cabinet is not acceptable if it has 20 demerit points or more.

An inspection report listing the

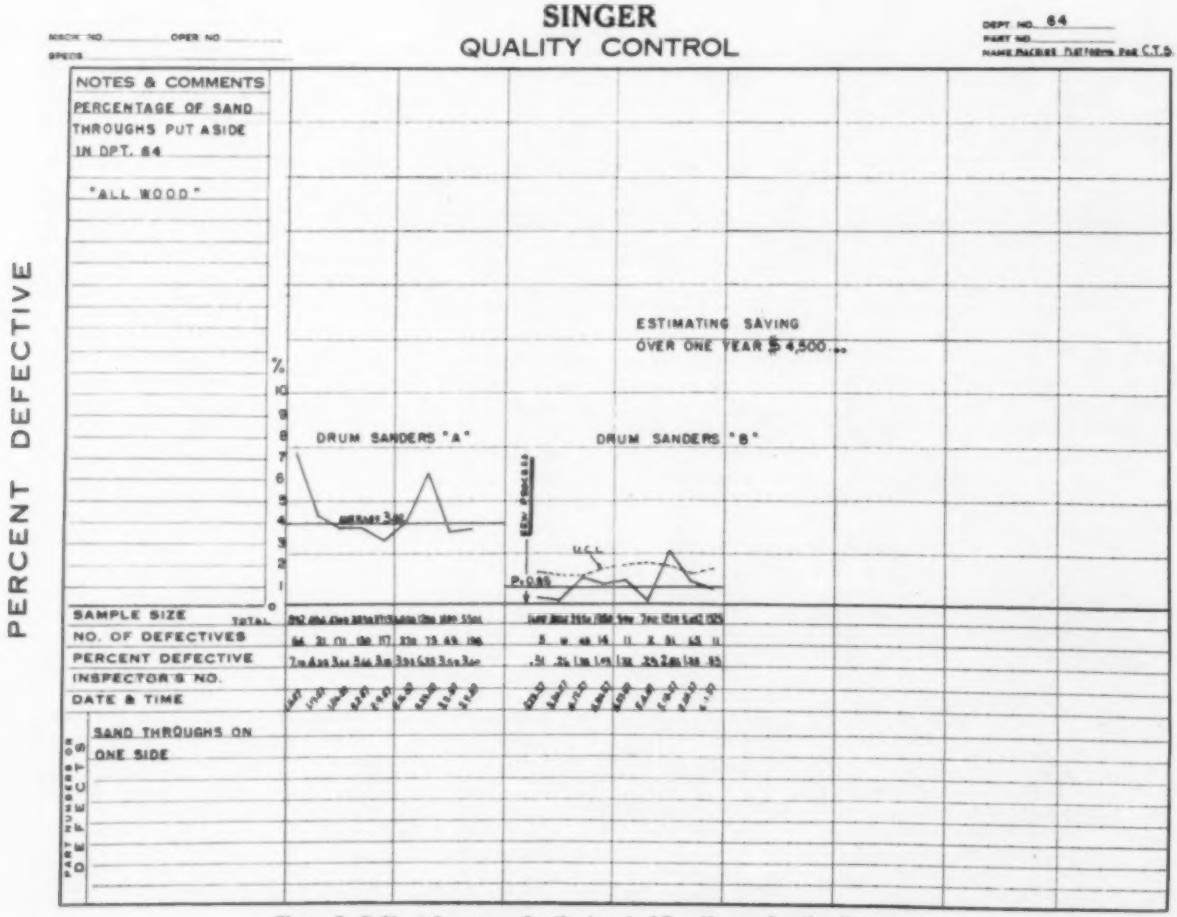


Figure 8—P Chart Compares Quality Level of Two Veneer Sanding Processes

defects, the demerits and the department concerned, is sent to all management levels interested. Looking at the average and range chart for general appearance, there are three quality performance pictures. (Fig. 2).

The following reasons have contributed most to the noted improvement.

(a) Eye test to all the inspection group, the stroke sander operators, and the touch-up men.

(b) Better lighting.

(c) Daily process sampling inspection by roving inspectors.

(d) Daily quality rating of goods ready to be shipped.

Among the above factors, a comment on the eye-test program is in order. It is a policy of the factory to have new employees pass a medical examination and have their eyes tested. According to the daily quality rating, the conclusion was reached that some inspectors did not see what they were supposed to see. Therefore, all inspectors had their eyes tested.

Again, the purpose is not to catch the faults but rather to prevent them. Hence, the eye test program was extended to the production group.

Quality Performance Reports to All Levels of Management

All production areas of the Cabinet Division are covered by four process quality controllers (roving inspectors) under a quality supervisor. Beside the function of this service and policing group to evaluate the quality at its source by sampling, specific items which require control are plotted on suitable quality control charts. The frequent quality assurance observations obtained by small sampling are entered on a special form. The stock moving on trucks from one department to another has an identification production card, which is stamped by the quality controller if the lot is accepted. When the same defects keep repeating, operations are sometimes stopped and a Quality Deviation Report is sent to people concerned. (Fig. 3).

From the foregoing data, a Weekly Summary Report of the quality and major defects is communicated to all levels of management. (Fig. 4).

In addition to giving top management a bird's eye view of the factory quality performance, the corrective action group and the process inspector are kept on the alert.

Twice monthly, woodwork stock ready to be shipped is unpacked and inspected by the Quality Control Manager in the presence of the top management group. Faults are evaluated by demerits and again reported to all department managers concerned.

Every three months, a Singer New York executive office delegate makes a representative sampling inspection of the stock ready for export.

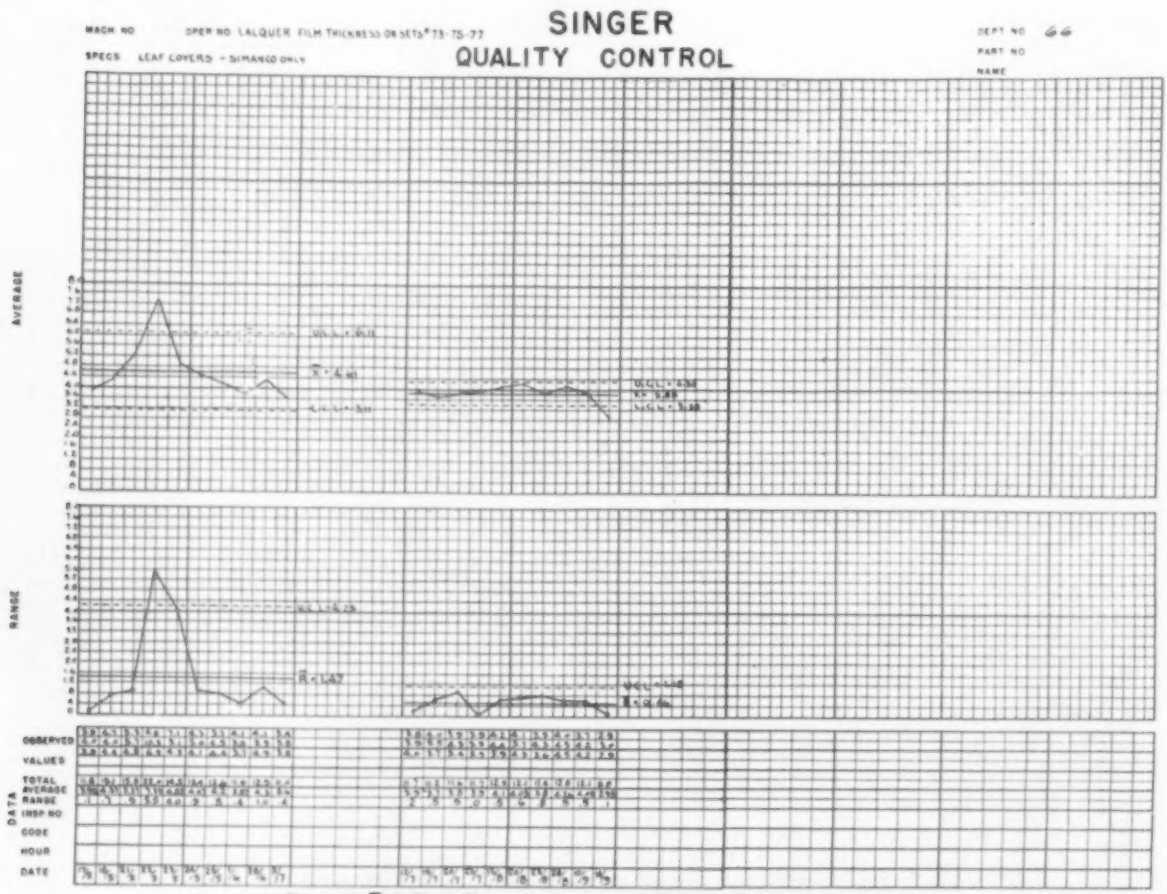


Figure 9—$\bar{X}$, R Chart Shows Improvement in Lacquer Thickness Control

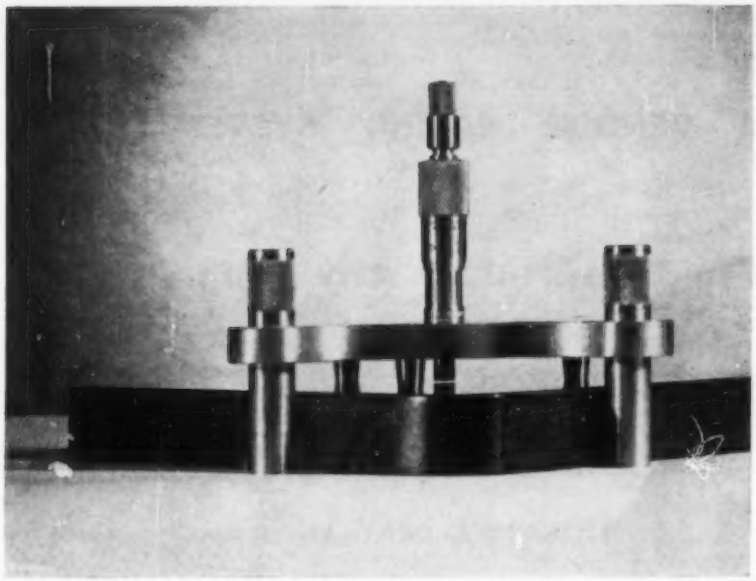


Figure 10—A Home-Grown Device for Measuring Lacquer Thickness

Statistical Quality Control Charts

A number of different types of charts are currently used in process quality control. These cost reduction and quality improvement tools have a very great psychological effect on the production group. It has been found that a chart placed beside an operator, picturing his performance, is worth a supervisor.

The quality control charts have an important distinction in the technical language of statistics. One type of chart called "Variable or Average and Range" ($\overline{X}$ & R) chart can be used only where it is possible to measure the variation, such as lacquer film and veneer thickness, glossmeter readings, and so forth. It can be used on appearance also, but with a system of demerit points. This type of chart is more sensitive to quality deviations than are other types of charts.

Two other control charts are used for attributes. One of these, called the P chart, is used to evaluate the fraction defective, such as the results given by the appearance of a piece of furniture: it is either good or bad.

Another attribute chart, called the "U" chart, pictures the number of defects per unit, such as the number of defects on a drawer, on a cover, or on a complete cabinet.

A fourth simple control technique is the frequency distribution. This powerful tool can be used very easily. In tabulating the sizes of one or two hundred parts, the variation pattern that can be expected from a process is pictured.

The chart techniques are well explained in available manuals and textbooks. A few of these charts, and what they have accomplished are shown.

The frequency distribution in Fig. 5 shows two patterns: before and after the supplier was notified. The first pattern shows that 14 percent of the parts are off specification, while the second pattern is within an acceptable range.

Being aware of what Singer will not accept, we prefer to think that the supplier corrected his process to give less variation. Otherwise, the 14 percent defective parts shown would have been too excessive to live with. However, if the process of the vendor was not corrected and parts were sorted out, it is to his disadvantage, but our firm gets the part to the right specification, which is the protection we are after.

Fig. 6 is a U chart used on sewing machine cabinet covers after polishing operation. Note the quality improvement over one year. This improvement has reduced the touching-up operation and was achieved through better handling, a greater desire to produce quality, and a superior polishing operation.

The P chart in Fig. 7 is very significant. The chipped moulding caused by the feed speed at a hinge seat operation has dropped from 3 percent to less than 1 percent. The operator was feeding too fast. The savings are estimated to be $1,000.00 per year.

The P chart in Fig. 8 illustrates the sand-throughs of veneered panels of two different processes. The savings figure for a few other similar parts represents approximately $30,000.00. This quality cost reduction is credited to the production management and the engineering department.

Fig. 9 is a chart of the average and range type, controlling lacquer film thickness. Fig. 10 illustrates the fact that sometimes you have to construct your own measuring device.

The instrument is set on a given corner and the micrometer is brought against the finish surface. The instrument is then removed and the lacquer under the micrometer head is washed off with a solvent on an area of approximately the size of a five cent piece. A second reading is then taken, and the difference is the dimension wanted.

We have also applied most of the procedures shown here in other divisions, such as the Foundry, Motor and Metal Divisions, and they have been found equally successful in these areas.

Conclusion

Statistical quality control is a powerful tool with which it is possible to picture a process at a given operation. It becomes a decision-making service on which management's actions can be based. The quality control pictures represent the expected variation pattern given by the process, whether the results are favorable or not.

These pictures, or charts, are interpreted by an impartial quality control group and are then submitted to the production and the engineering staffs for corrective action. Therefore, quality control becomes a team job and it is important to sell the quality control idea . . . not to impose it.

If speed is wanted, give the credit to the production management and engineering groups. The whole factory soon will be trying to improve the product and reduce the quality cost, which, after all, is the main objective.

The question is not "Can we afford to use quality control?", but rather, "Can we afford not to use quality control?"

Accurate

Simple

Economical

Informative

Adaptable

Understandable

A VENDOR RATING SYSTEM

For Material of Any Complexity

LEONARD E. GRAY, *ASQC Member, Falls Church, Va.*

Introduction

THIS is a description of a vendor-rating system developed and being used by a medium-sized company whose products are small quantities of high-quality electronic and precision electro-mechanical equipments made to military specifications and rigid company requirements. Because it purchases, for use in production, not only simple stock items but also some complicated and expensive sub-assemblies with many characteristics to inspect, the company needed a rating system that could be used for purchased units of any complexity.

AQL System Not Adequate

A vendor-rating system based on the ratio of the process average to the AQL would not have been satisfactory. To be even reasonably adequate, it would have required setting up a separate AQL for each purchased item, based on defects per unit (the company referred to uses the fraction-defective type of AQL for its MIL-STD-105A sampling plan) and the recognition of critical, major, and minor defects. Considering the variety of items procured, such a system would have been very expensive. It would not have given very precise ratings because it would have required the conversion of inspection variables to attributes, with the consequent loss of information. Consider two inspected pieces:

Piece No. 1	Piece No. 2
"Critical" defect	"Minor" defect
Required: 1.8325 ± 0.0004	Required 3½ ± 1/64
Inspector found: 1.8330 (0.0001 above the allowed top limit)	Inspector found: 3¾ (15/64 above the allowed top limit)

Piece No. 1 would almost certainly be within the engineering safety factor and acceptable "as is" with no detriment to the end item, but Piece No. 2 would probably be scrapped or returned to the vendor as unusable. Yet an AQL-type rating system would give more demerits to the vendor of Piece No. 1. In other words, a vendor-rating system based only on degree of compliance with AQL does not consider *how far out of tolerance* a defect is, or the cost to the purchasing company of rectifying the defect, even if critical, major, and minor defects are handled differently. The essence of an effective vendor-rating system is its ability to distinguish between degrees of defectiveness—from disabling defects at one extreme to nominal defects at the other extreme.

Disposition of Defective Pieces

The new vendor-rating system described here makes mathematical use of the seriousness of defects, without an excessive administrative cost, by using data already available—the purchasing company's reports on the disposition of discrepant material. A Defective Material Report is prepared for each received lot which contains one or more defects, and a copy of the form was already being sent to the QC Department before the rating system was developed. The most common dispositions of discrepant purchased material are:

Accept as is (AAI)—because defects are not serious enough for rework

Rework (REW)—at purchasing company's expense

Return to vendor (RTV)—for repair or replacement at vendor's expense

The approximate relative costs to the purchasing company for shop time, added paper work, and schedule delays are as follows for the various dispositions:

Disposition	Relative Cost
AAI	1
REW	5
RTV	10

Relative Demerits

The 1, 5, and 10 weightings are therefore the relative demerits to be given by the ratings for the corresponding dispositions of discrepant material. Note that it is worse to have to return an item to the vendor and let him correct it than to rework it in the purchaser's plant. Not only are production

ASQC LCS Code 351:40:400

schedules delayed by the return to the vendor, but there is also the cost of added paper work and re-inspection when the item comes back. Also, rework done by the purchasing company is usually of a minor nature, such as deburring or paint touch-up; pieces with more serious defects are usually returned to the vendor.*

A good vendor-rating system needs more than these weighting factors for disposition. It should distinguish between Vendor A, whose item had ten defects and was reworked, say, and Vendor B, whose item had one defect and was reworked. So that Vendor A will be given the poorer rating he deserves, the number of defects should be added as a factor in the rating system. The more complex the part, the more important is this factor—number of defects—in the rating system. For simpler parts, the weightings for disposition are more important.

Basic Equation

The basic equation, then, for a vendor's raw rating under this system is:

$$r = \frac{DEF + AAI + 5\ REW + 10\ RTV}{n} \quad (1)$$

r: Raw rating, or number of demerits

DEF: Number of defects in all pieces received

AAI: Pieces accepted "as is" } Defective Pieces

REW: Pieces reworked by the purchasing company } Defective Pieces

RTV: Pieces returned to the vendor } Defective Pieces

n: Total pieces received

Figures used in Equation (1) are totals for the month. All the pieces in each lot are considered. If inspection of a given lot is by sampling, the remainder of the lot is treated as if it had the same fraction defective as that found in the first sample. This may not be true, of course, but it's a necessary assumption in order to give the proper weighting to large lots.

Product Groups

In order to separate the vendors into fairly homogeneous groups, so that one vendor's rating would be comparable with another's even though they manufactured different types of material, broadly inclusive product groups were established. A partial list of these is given in Table I.

Table I

1. Plastic parts and assemblies
2. Machined parts and assemblies
3. Sheet-metal and weldments
4. Relays and solenoids
5. Transformers and inductors

But there are wide variations of product complexity in some of these groups, so a further breakdown by unit cost was made. An example of this breakdown is illustrated in Table II.

Table II

Plastic parts and assemblies (from Table I)
- a. Unit cost $1 to $10
- b. Unit cost $11 to $100
- c. Unit cost $101 to $500
- d. Unit cost $501 to $2000
- e. Unit cost over $2000

A similar break-down was made for the other groups in Table I. Cost of product was used as the criterion because, within a product group, it is a rough measure of complexity—that is, of opportunities for the existence of defects—and because it was easily obtainable. The cost of a purchased item is listed on the Purchase Order, which the inspector uses in conjunction with blueprints and specifications when he inspects the material.

Each vendor was then given a monthly rating, using Equation (1), for each sub-group. A vendor might have these sub-group ratings in 1a, 1b, and 1d, for example.

Final Ratings For Sub-Groups

At this stage in the development of the system, fairly accurate ratings were obtained at a reasonable administrative cost, but the rating number was not suitable for presentation to people outside the QC Department. Higher numbers meant poorer quality (this is a bad feature if the ratings are for general distribution), but there was no basis for comparing vendors in different product groups.

Conversion of the raw ratings into more easily understandable and comparable numbers was accomplished by using Equation (2):

$$R = 100 - 25\ r/m \quad (2)$$

R: Final rating for the sub-group (one vendor)

r: Raw rating (Equation 1)

m: Historical average of r for all vendors in the sub-group, weighted by pieces.*

This final rating compares each vendor's current quality with the long-term average rating for all vendors in the same product sub-group, thus making allowance for the complexity of the product—the number of defects likely to exist in a unit—and allowing a comparison of vendors in different product groups.

Also, it converts the raw ratings, which would be just meaningless numbers to an outsider, into familiar looking ones similar to school grades, with 100 for perfect, 75

*This average is revised quarterly.

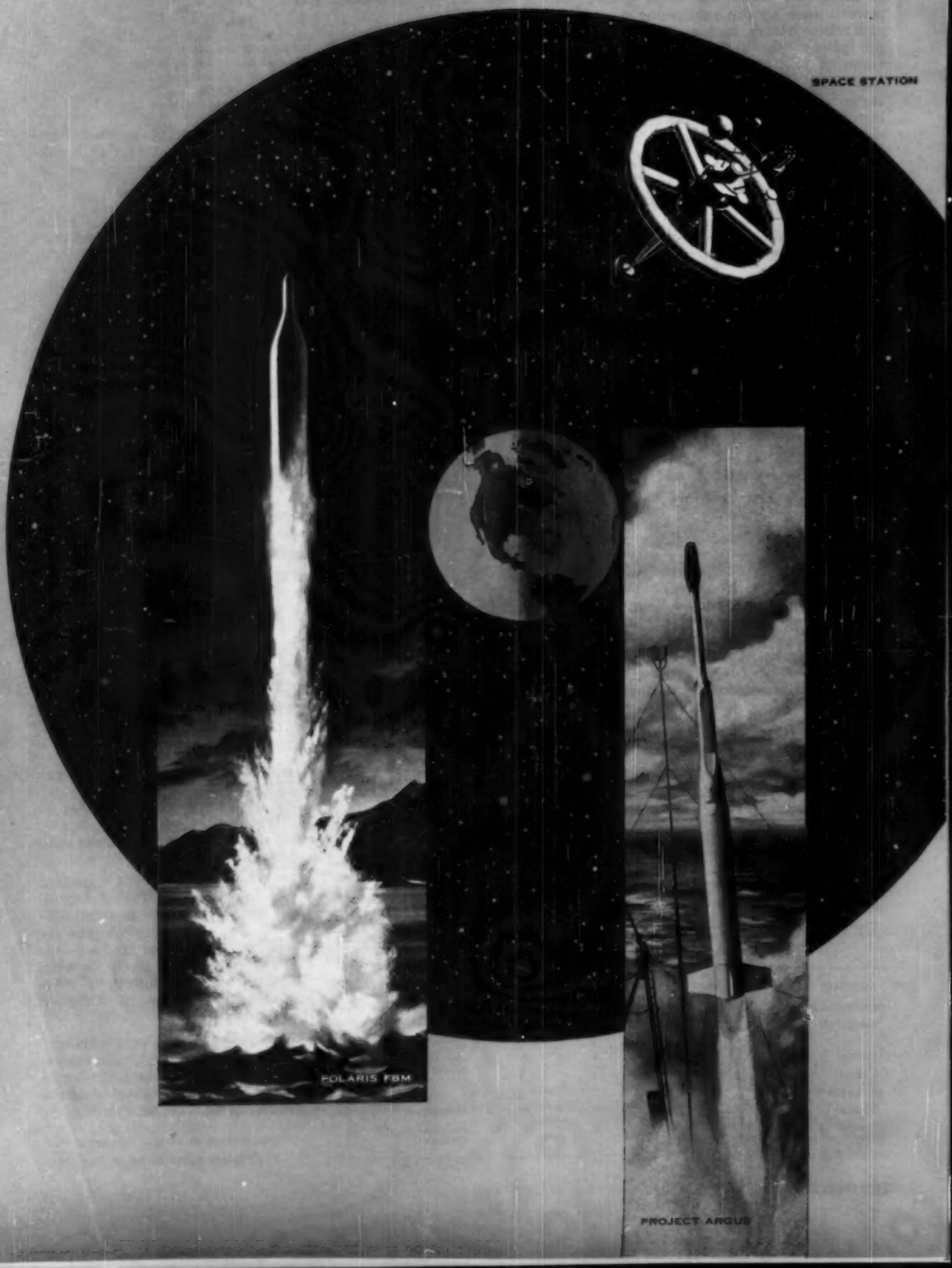
(Please turn to page 30)

*Not many pieces are scrapped, but the few that are scrapped are given the same weighting as units returned to the vendor. Nominal rework, such as stamping with the part number, is weighted the same as for material accepted as is. If a piece has more than one disposition (for more than one defect), the most severe disposition is the one assigned. If some defects in a part are accepted as is and others are reworked, for example, the whole part is considered as reworked and charged as such.

Table III — Vendors with Poor or Average Ratings

Vendor - Rating Report — August 1960

VENDOR	RATING Jun.	Jul.	Aug.	PCS REC	PCS O.K.	PCS AAI	PCS REW	PCS RTV	Defects Total	Description	No.
MACHINED PARTS AND ASSEMBLIES											
Vendor A	98	82	63	320	280	5	15	20	45	Dimensions	25
										Holes omitted	15
										Misc.	5
Vendor B	72	84	76	18	12	6	0	0	20	Concentricity	12
										Other dimens.	8
(Etc.)											
PLASTICS											
Vendor C	39	53	50	4	0	4	0	0	8	Scratches	8
Vendor D	72	79	61	230	210	0	0	20	40	Delamination	20
										Cracks	20
(Etc.)											


SPACE STATION
POLARIS FBM
PROJECT ARGUS

DISCOVERER SATELLITE

EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

ADVANCED PROJECTS AT LOCKHEED

POLARIS FBM—Now in its advanced development status, the Navy-Lockheed POLARIS Fleet Ballistic Missile is scheduled to be fully operational and aboard its specially designed submarines late this year. Full-scale test vehicles have been successfully flown on a regular schedule of firings for months with only two failures, a remarkable achievement in view of the totally different environmental problems involved in its underwater launch. With nearly three-quarters of the earth's surface being water, practically no target in the world is outside the POLARIS' range of over 1200 nautical miles. The Division is systems manager for the POLARIS under the direction of the Special Projects Office of the Navy.

SATELLITE PROGRAMS—The Air Force-Lockheed AGENA satellite is a versatile space vehicle capable of numerous assignments. In its present DISCOVERER program configuration, it is 19 feet long, 5 feet in diameter with an orbital weight of approximately 1700 pounds. Payload of several hundred pounds includes telemetry, instrumentation, guidance and attitude control systems, reentry vehicle and recovery capsule. The AGENA has accomplished several significant space "firsts." It was first to be placed on the difficult polar orbit; first to be placed on a precise, predicted, and nearly circular orbit; first to change its attitude on orbit, with a turn of 180 degrees and a downward tilt of 60 degrees; first to eject a capsule; and first to prove advanced space systems such as ground-space communications, instrumentation, attitude and guidance and life-sustaining devices. The AGENA can be modified for a variety of space missions such as navigation; geophysical investigations; lunar probes; long-range communications; and space probes.

In addition to the DISCOVERER program, the Division is developing advanced AGENA satellites for the MIDAS program (Missile Defense Alarm System) and the SAMOS strategic warning system. Lockheed is system manager and prime contractor for these projects under the direction of the Air Force Ballistic Missile Division (ARDC).

SPACE STATION—An orbiting research facility to serve as an advanced base for space exploration, has been proposed in practical detail by Lockheed's research and development staff. The station would carry a 10-man crew. Prefabricated compartments for the rim of the wheel, the spokes, and the three hubs would be launched separately by ballistic missiles and assembled in space by means of the specially-designed, Lockheed Astrotug.

X-17, KINGFISHER, X-7—The Air Force-Lockheed X-17 solid-propellant ballistic missile has pioneered many new techniques, and the valuable experience gained from this program facilitated development of other, inter-service projects, including the Navy POLARIS FBM. The Navy's Project Argus radiation explosion featured the X-17 as the vehicle. Developed for the Air Force, the Lockheed KINGFISHER is designed to simulate enemy attacks to test our nation's anti-bomber and anti-guided-missile defenses. The Air Force X-7 is a unique, recoverable ramjet-engine test vehicle designed to test new developments in advanced components for other missiles.

The successful completion of projects such as these requires a bold and imaginative approach to entirely new environments. Lockheed's programs reach far into the future. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. I-23, 962 W. El Camino Real, Sunnyvale, California. U. S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / MISSILES AND SPACE DIVISION

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA

CAPE CANAVERAL, FLORIDA • HAWAII

for average, and below 50 for very poor. (Any rating that comes out a minus number is called zero.)

Net Ratings for Broad Product Groups

The one remaining problem in presenting the ratings was a simple one: how to combine the small-sub-group ratings (see Table II for examples of the sub-groups) for each vendor into one net rating for each broad product group (for example, machined parts and assemblies, as in Table I).

This was done by using the average of the vendor's sub-group ratings (within a broad product group), weighted by dollar value:

$$R_t = \frac{\Sigma(cR)}{\Sigma c} \qquad (3)$$

R_t: Net rating for vendor in a broad product group
c: Cost of merchandise in each sub-group
R: Final rating in each sub-group

Dollars are used for weighting, rather than pieces, because it would hardly be logical, as an example, to give more weight to 100 simple machinings costing $1 each than to 20 complex ones costing $100 each. Weighting by dollars puts the emphasis on the place where the money is being spent.

This results in one net rating for each machining vendor, one for each plastics vendor, and so forth. A vendor who has sold the company items in more than one broad group — machined parts and assemblies and sheet-metal and weldments, for example — will get one net rating for each of the broad groups in which he appears. This is the final form of the ratings — the one published in the monthly reports.

Rating Reports

Monthly reports are published in the form illustrated by Table III for vendors with poor or average ratings (below 80).

The rating numbers give an overall evaluation of each vendor and show the trend of each one's quality. Vendor A, in the example, should be warned that he has been slipping badly; consideration would probably be given to discontinuing business with Vendor C. The figures for defects and defectives are an important part of the report because they give the buyer or liaison man specific information for his discussion with the vendor. If a vendor is told he had a rating of 50 in the past month, for example, he might ask, "How many pieces were defective? What were the defects?" and the contact man should be able to tell him.

In a separate section of the report, vendors with good ratings are listed briefly, as in Table IV.

Table IV — Vendors with Good Ratings

Vendor-Rating Report — August 1960

Vendor	Product Group	Rating Jun.	Rating July	Rating Aug.	Pcs. Aug.
Vendor E	Machined pts. & assem.	78	65	100	10
Vendor F	Machined pts. & assem.	90	85	94	426
(Etc.)					
Vendor G	Plastic parts & assem.	57	83	81	35
Vendor H	Plastic parts & assem.	97	92	90	360
(Etc.)					

Collecting the Data

As the QC copies of the Inspection Reports are received during the month, the following items are added to each form:

1. Code for product group.
2. Code for defects, if any.
3. Disposition of defectives (from the QC copy of the Defective Material Report), if any.

At the end of the month, the Inspection Reports for all vendors to be rated* are arranged alphabetically by vendor and, for each vendor, by product group. They are then summarized and the reports are prepared.† A QC engineer audits each stage.

Conclusion

This new vendor-rating system was designed to satisfy the following requirements:

1. Accuracy, including discrimination of degrees of seriousness of defects.
2. Simplicity and low administrative cost, gained by using existing paper work where possible.
3. Informative ability and easy comparison of one vendor with another.
4. Adaptability to all types of product being bought, from very simple to very complex.
5. The use of formulas readily understood by people not trained in mathematics.
6. Simple conversion to the use of IBM machinery.

In the company which developed this system, the monthly reports have been well received and have even been requested by people not on the regular distribution list. Included in the distribution list are department heads and other key personnel in the following departments and sections:

1. Purchasing
2. Quality Control and Quality Assurance
3. Inspection
4. Engineering
5. Planning

Example

Table V shows how the ratings are computed for one vendor in one broad product group:

*Most manufacturers are rated; wholesalers are not.
†Only vendors who have shipped at least $500 worth of material during the month are listed on the report.

Table V — Vendor J, Product Group A — Machined Parts and Assemblies

Total Receipts for August

$	Sub-Group	PCS REC	PCS AAI	PCS REW	PCS RTV	No. Defects	r (1)	R (2)
532	A1	287	66	2	0	73	$r = \frac{73 + 66 + (5 \times 2)}{287} = 0.52$	$R = 100 - 25\frac{0.52}{0.60} = 78$
16420	A3	49	2	10	1	57	$r = \frac{57 + 2 + (5 \times 10) + (10 \times 1)}{49} = 2.43$	$R = 100 - 25\frac{2.43}{2.60} = 77$
7219	A4	10	6	2	0	52	$r = \frac{52 + 6 + (5 \times 2)}{10} = 6.80$	$R = 100 - 25\frac{6.80}{4.80} = 65$

(3) $R_t = \frac{(532 \times 78) + (16420 \times 77) + (7219 \times 65)}{532 + 16420 + 7219} = 73$

Note: Sub-group averages (m) in the example were assumed to be 0.60, 2.60, and 4.80, respectively, for A1, A3, and A4.

Cost Of Reliability

BEN I. FUNK, *Norton AFB, California*

The issue of reliability is very directly related to cost. However, reliability must be considered simply as another major factor in achieving weapons system effectiveness, not as an end in itself.

This point of view directs attention to a complex problem; namely, the problem of how to budget for reliability.

The purpose of this article is to confront this problem of cost in the hope that these comments might accelerate progress in reliability and, at the same time, help to keep costs within reason.

I'm particularly concerned, of course, that we achieve this progress as economically as possible. This country does not have inexhaustible resources. The reliability job must be achieved at minimum cost.

It is not my purpose here to suggest or to state official policies of the Air Force or of the Department of Defense. Rather, among engineers and scientists, I am attempting to confront a difficult subject academically and to state what I personally think about planning and budgeting for reliability.

ASQC LCS Codes 800:10;30;40;60;70:419
Paper presented by Ben I. Funk, Major General, USAF, Commander, San Bernardino Air Materiel Area (AMC), on the program of the one-day Reliability Symposium sponsored by the Los Angeles section, ASQC, February, 1960.

Performance vesus Reliability

In considering the problem of the cost of reliability, it is important that we all start from the same point of reference.

In this regard, there are certain fundamental concepts which must be clearly recognized.

The first of these concepts concerns the difference between performance and reliability. Without getting into the hair-splitting questions of definitions, I think we can agree that performance relates to the ability (or capability) of an item to perform a specific function.

Reliability, on the other hand, relates to the repeatability of this performance.

We might look at this distinction in terms of two questions that might be asked in developing an item:

1. What combination of parts will yield a desired effect?
2. How many times or how long will it yield this effect without failure?

The answers to these questions require different types of analysis. It is important that we recognize this distinction in understanding the relationship between reliability and cost.

Let's look now at the next concept — that of quantitative reliability.

Quantitative Reliability

Frequently the question is raised — "Aren't we already paying for 'reliable' equipment?" Actually, the term "reliable" has little meaning when used in this context. It is similar to terms like good or pure. Equipment reliability has meaning only when expressed in quantitative terms.

To emphasize this point let's look at an analogy. When the Air Force buys liquid oxygen we never ask for "pure" liquid oxygen — we ask for some level of purity. For example, we might say that this oxygen shall contain no more than 1,000 parts per million of impurities (such as carbon dioxide, moisture, acetelyne, etc.) Or, we might ask for no more than 100 parts per million or 10 parts per million. The point is that we have defined "pure" in terms of a level of purity that can be measured or observed.

In our missile and space contracts reliability has been expressed both as a minimum requirement and as a design goal or overall reliability objective. The use of both a minimum value and design objective recognizes the fact that it is extremely difficult to determine the optimum value of reliability which we desire.

Now let's look at some other concepts.

Current Reliability

The word *current* may not be the appropriate word, but the point is that there is some level of reliability which might be reasonably expected using existing components and design practice.

For example, if we know the mean life and the number of parts, we can predict the reliability using certain assumptions. In this regard, some reasonably effective prediction techniques have been developed for application to electronic equipment.

There is much yet to be learned regarding the prediction of reliability; however, the point I am trying to make is that there is some level of reliability represented by the existing state-of-the-art, and it can be predicted even though this prediction may be crude.

Reliability Improvement

Now if the "current" reliability is less than the "required" reliability, which is almost always true in our new, more complex weapons, then reliability improvement is necessary.

This improvement might be to increase the mean life of some vacuum tube through redesign, or to improve the capability of a manufacturing process, or to provide more stringent receiving inspection on certain components, or to use redundant circuits and components, or many other types of actions.

The point is that this improvement requires specific effort to be expended, and therefore involves cost. It is well known how rapidly mean life requirements increase with increases in reliability requirements.

So, if we are talking about a system with a high reliability requirement, and if the system has many components, we may be asking for mean life of components which are astronomical.

To summarize up this point:

1. Reliability is a specific thing that can be quantitatively expressed and measured, although present methods and techniques are crude.
2. There is an existing or "current" level and a "desired" level.
3. To improve from "current" to "desired" involves effort and this effort involves costs.

Now let's look at some cost relationships.

Let us consider for the moment two major categories — development costs and operational costs.

Mission Cost vs Reliability

In using only two broad categories we must recognize that a multitude of factors are included within each category. However, this simple breakdown does emphasize the contrast of the one-time outlays for research and development against the investment and recurring operating expense of the procurement and maintenance activities. This distinction will permit a better measurement of the economic impact in terms of research and development costs against the total cost of the operation over the expected useful life of the systems. *One way to define the optimum reliability for a weapon system is to seek that value of the reliability which minimizes total mission cost.*

For example, the mission might be to place a specific number of warheads on target, when required; the cost to maintain this capability, say for one year, can be called the total mission cost. It includes the cost of hardware development, facilities, missiles, supplies, training, etc. — everything necessary to establish and maintain the military capability.

The mission cost is then composed of the operational costs and the development costs. When we look at the operational costs, it is obvious that as reliability decreases, operational cost increases.

For example, at a reliability of 50 percent, twice as many weapons and launch facilities etc. would be required to accomplish the same mission. If the reliability were zero percent, the operational costs would be infinite.

Looking at development costs it is also obvious that to obtain increased reliability, increased development effort will be required. If we attempt to approach 100 percent reliability, the development costs become infinite.

Since the cost of the mission is the sum of operational costs and development costs, it can be seen that there is some point of "optimum reliability" from an economic viewpoint.

There is one basic fact, from all of this, which I want to stress. The important relationship is the cost of reliability to TOTAL mission cost — not the relationship between the cost of reliability and other development costs.

Cost of Reliability During Development

I personally believe that in order to approach the "optimum reliability" more closely we must aggressively pursue a higher level of reliability during design and development. I think that in theory, at least, the overall operational reliability cannot exceed the reliability of the design. Obviously, effective additional effort in this area would reduce the total mission cost. However, the reliability of design can only be enhanced by design action.

In line with this point of view, the Air Force has gone to great pains to emphasize to management the absolute necessity of incorporating reliability thinking and action into all aspects of weapons development and for subsequent conformance to these requirements during production. This is dramatically reflected in the Air Force Ballistic Missile Exhibit 58-10 entitled, "Reliability Requirements for Ballistic Missiles and Space Systems." This exhibit references specific requirements of Weapon Systems, Electronics and other related reliability specifications for specific categories of subsystems.

Also, the Aeronautical Systems Center at Wright-Patterson Air Force Base has a Reliability specification delineating specific requirements for aircraft and missiles other than ballistic.

All of these specifications have one thing in common — they emphasize the importance of certain details of technical procedure and management that collectively enhance the probability that a missile will be reliable. However, these specifications also contain requirements that are intrinsic to effective engineering and industrial management in weapons.

There is a strong tendency in some industries, however, to consider all reliability requirements as something "extra." This is like a haberdasher who offers to sell a new fedora for $10 and a few minutes later qualifies his price by saying that a fedora *that really fits* will cost $12. One simply does not buy a hat that doesn't fit.

We all recognize that increased effort in any area necessitates extra expenditures. The Air Force,

just as any other customer, must be willing to pay for those specific costs incurred to improve reliability; however, we must separate the traditional and basic elements of good management and engineering from those unusual and justifiable expenditures for higher reliability achievement. *We must insist that the term "reliability" not be used as camouflage for additional charges for those functions which are an intrinsic part of an effective industrial operation.* What are some of the specific costs?

Specific Costs

I have stated before that ballistic missile or space system contractors are given a specific quantitative reliability requirement for their portion of the weapon system. One of the contractors' first jobs is to apportion these throughout his major subsystems and then from the subsystem level to next lower level. This isn't an easy task. It involves a thorough analysis of the system with an attempt to minimize the stretching of the state-of-the-art within the various components of the system. As reliability knowledge is gained it will probably be necessary to reapportion the reliability requirements a number of times.

When the designer establishes his paper layout of components it is necessary to start predicting the reliability of the system. This may result in immediate changes in design through use of different types of components, different layouts, redundant systems, etc. It may also indicate the need for higher component reliability.

Considerable effort is required at the part level. Parts must be procured for evaluation tests, parts selection tests, and failure analysis. Investigation must be made of each part failure to verify the cause of the failure by duplication of the conditions under which the failure occurred, physical and chemical analysis of the failed part, and special testing to determine the mechanism of failure. Failure data reporting and analysis is an obvious cost.

Since part reliability measurement and prediction techniques can never consider all the interactions involved, it is necessary to establish tests to measure the subsystem and systems reliability attained. These can be separate tests or part of other tests; however, they involve test planning and evaluation by reliability specialists.

I have endeavored to indicate here a few of the specific activities that are required by a contractor to achieve the quantitative reliability values specified in the contracts. The point is that there are concrete and definable activities that must be performed and the costs of these activities can and should be identified with the specific actions required to achieve the desired reliability.

Where costs are allocated isn't too important as long as the same costs are not included in several places. For example, if the cost of qualification testing is imbedded in the cost identified under reliability, then this effort must *not* be included in standard costs for the design effort.

Air Force Action

I have already mentioned a few things that are needed to relate cost and reliability more closely. The Air Force has taken concrete actions and will continue to pursue those areas under its direct control or influence.

In the area of reliability measurement, the Ballistic Missile Center has utilized special consulting services.

Weapon System analyses have been performed to try to arrive at the optimum distribution of funds between research and development, production, and operation and maintenance costs. A general shift towards spending more R&D money to increase overall expenditure effectiveness is taking place.

As further evidence of the cost consciousness of the Air Force there is now in being a program for the interchange of component test data among all ballistic missile and space system contractors of all three services—a program I am happy to say, which was originally sponsored by the Air Force Ballistic Missile Complex in Inglewood, Calif. These data should help accelerate the attainment of higher reliability and reduce duplication of costs.

Summary

First, the achievement of the quantitative reliability requirements in the contract requires that specific, tangible, measurable actions be performed by the contractor.

Second, there is some level of reliability in existing weapon systems, but this level of reliability must be raised.

Third, *increasing* the reliability of a weapon system requires additional efforts and additional costs.

Finally, the cost of reliability must be minimized through the combined efforts of industry and the Air Force to develop better methods of attaining reliability and better techniques of measuring our results.

These considerations, I repeat, represent my own personal view of a problem. This view is colored vividly by my day-by-day struggle to stretch the dollar to provide for the immense expenses of our weapons program.

It is incumbent on all of us to spare no technical effort to achieve the reliability we so urgently need.

It is equally incumbent on all of us to do the reliability job with a sincere respect for the economic health of our country.

Food and Allied Industries Steering Committee To Form ASQC Division During 1960-61

The Food and Allied Industries Steering Committee is organizing to achieve the status of an ASQC Division during the 1960-61 fiscal year.

This new division will be concerned with the application of quality control to food and allied processes. Its purpose is to provide a medium of exchange of statistical quality control information in these industries and to consider the quality control problems unique to this field.

For additional information, QC personnel in the food and allied industries are urged to contact either William A. Golomski, chairman, c/o H. J. Mayer and Sons, 6811 S. Ashland Ave., Chicago 36, Ill., or Mae-Goodwin Tarver, secretary-treasurer, c/o Continental Can Co., Inc., 1350 W. 76th St., Chicago 20, Ill.

BOOK REVIEWS

W. D. Baten, Editor

26 University Drive, East Lansing, Mich.

STATISTICAL QUALITY CONTROL: An Introduction for Management by D. H. W. Allan, published by the Reinhold Publishing Co., New York, N.Y., pages 1-129, $3.50. Reviewed by I. A. DeGrote, Engine and Foundry Division, Ford Motor Co., Dearborn, Mich.

This is a brief and concise non-mathematical explanation (125 pages) of Statistical Quality Control — what it is, where it fits into an organization and why and how it is used.

It is written in terms that can be readily understood by the uninitiated and is short enough that even the busy executive should find time to read it.

The subject is covered under eight major headings: Statistical Quality Control Objectives, Statistical Quality Control in the Organization, Some Elementary Statistical Concepts, Process Capabilities, Statistical Control Charts, Statistical Acceptance Sampling, Statistical Methods for Investigation and Experimentation, and Sources of Quality Control Information.

The first two chapters explain what Statistical Quality Control is and where it fits into an organization.

Chapter three explains the need for reliable data and some of the concepts and simple statistical terminology, including the average, range, frequency distributions, standard deviation, the different types of distributions etc.

Chapter four describes the reasons for making process capability studies, the method used and the analysis and interpretation of the data.

Chapter five covers the control charts and the reasons why the average and range charts are superior to the plotting of individuals, and the use of the fraction defective and "C" charts.

Chapter six involves acceptance sampling, the importance of using a statistical plan, the fallacy of using a percentage of the shipment as the sample size.

It explains the different plans briefly (single, double, sequential and variables) and the advantages and problems connected with each.

Chapter seven deals with methods used in experimentation and investigations. It briefly describes significance tests, Bartlett's test, Chi-square test, analysis of variance, the design of experiments, regression and correlation.

Chapter eight is a listing of books and references on quality control techniques and applications.

This book is not intended as a course in statistical quality control, but a "Cook Book" resume to give management (or anyone else who is not familiar with statistical methods) an overall look at statistical quality control — what it is and why it can be a valuable tool.

Since any quality control program must have the support of management to be successful, it is imperative that they understand what it will do for them. If you can persuade your supervisors to read this book, I believe it will at least help to reduce any resistance they may have had to the use of statistical control methods.

QUALITY CONTROL AND INDUSTRIAL STATISTICS by Acheson J. Duncan, Ph.D., published by Richard D. Irwin, Inc., 1959, Pages vii-946. Reviewed by W. D. Baten, Michigan State Univ.

This well written book contains a vast amount of pertinent information about the many phases of quality control; it can be used effectively by professors of college courses in this subject, quality control personnel in industries, chief inspectors, statisticians and everyone interested in quality control by statistical methods.

The first part treats of fundamentals necessary and basic to understanding controlling quality of products such as: probability, various probability distributions as the binomial, Poisson, normal, hypergeometric and distributions of linear functions of chance variables, of products and quotients together with sampling distributions of arithmetic averages, variance, ranges and proportions. Use of t-values and lengths of run of any one class are explained.

The second part presents lot acceptance sampling plans which include single, double, sequential sampling plans, Wald's sequential probability ratio plans, sequential group and multiple-sampling plans with derivations of sampling plans with specified AQL, p_t, consumers' and producers' risks. Here are details of sampling plans of the Department of Defense which involve normal, tightened, reduced inspection and determination of acceptability. The chapters on acceptance sampling by variables are clear, well presented and very informative.

The author has done an excellent piece of work on how to construct operating characteristic curves for the various sampling plans. This book has in it more information about OC curves than any that the reviewer has ever read.

The third part contains material about rectifying inspection which means sampling when all rejected lots are replaced by 100 percent good ones. Here are presented ideas concerning average outgoing quality, average outgoing quality limit, average amount of inspection under certain conditions, number in the sample for given lot size together with details for using single, and double sampling tables. Sampling plans for continuous production are discussed.

The fourth part discusses quality control charts with their respective OC curves. The following control charts are

Our Cover

"Universal Inspection Machine"

A 40 to 70 percent time savings in checking aircraft part dimensions has been estimated by QC engineers of Convair—San Diego Division of General Dynamics Corp., who recently designed a "universal inspection machine" built around a closed circuit television system manufactured by the KIN TEL Division of Cohu Electronics Co.

Formerly large machined sections were fixed to a surface plate and measured with a height gage. A second measurement along another axis required a complete new set-up of the piece, a procedure that sometimes required several hours.

With the new system, the QC engineer aligns one edge of the test section along the cross hair on the TV monitor, records the vernier reading, and then moves the carriage assembly to the other side of the part. He makes a second reading, and subtracts the two figures to obtain the true dimension. Because the camera can be moved in both axis, he is able to repeat the procedure in the other direction.

In this way, he can check both dimensions without altering the position of the test part. The camera lens, focused by remote control, is a telephoto type which enlarges the field of view about 30x. The operator views the test part image on a KIN TEL 14 inch television monitor.

CREATE A COOPERATIVE ATMOSPHERE

With Elliott Quality and Reliability Motivators. Colorful and effective reminders that keep your program out-in-front where it belongs. Designed specifically to lower resistance and raise active employee participation.

More and more A.S.Q.C. members are finding it pays to fully investigate the many advantages of this tested and proved approach to greater cooperation from the work level.

Why not ask for your free samples today? No obligation — just forward the coupon below.

ELLIOTT
SERVICE COMPANY
30 N. MacQuesten Parkway
Mount Vernon, N. Y.

ELLIOTT SERVICE COMPANY, INC.
Dept. 9, Mount Vernon, N. Y.

Please provide me, without obligation, further information and multi-color samples of your Quality and Reliability Motivators.

NAME ..... TITLE .....
FIRM .....
ADDRESS .....
CITY ..... ZONE ..... STATE .....

considered, p-charts, np-charts, c-charts, u-charts, $\bar{X}$ charts, range-chart, standard deviation-charts, individual observation-charts, charts for the largest and smallest values and modified control limits for charts: The OC curves furnish interesting features of this book. This division closes with detailed ideas about lot plot technique, binomial probability paper, moving averages and moving range charts.

The last part is a small encyclopedia of statistics applied to industrial research and includes material on estimation of lot process characteristics with the use of inverse probability, maximum likelihood, confidence intervals for the universe average, variance and proportions under various assumptions about the value of σ with the determination of the size and sample, tests pertaining to differences between means and variances. The OC curves for the tests are very interesting.

A chapter is devoted to tests of normality by a test of the goodness of the fit and also by skewness and kurtosis. This is followed by contingency tables, Chi-square tests, a test of homogeneity of a set of percentages, comparisons of defects per unit, Poisson variables and the OC curves of χ^2-tests.

A large part of part five is taken up with analyses of variables; to my mind it is the best part of the book, for the author, in the beginning, laid down the underlying principles about these subjects, explained the methods for obtaining various sums of squares, presented very clearly the models that are to be used for various designs and introduced the reader to the proper error terms and indicated when interaction means squares can be used as error terms. This part of the book does not leave the reader in doubt as to how to obtain proper F-tests for many designs.

There is material on one-way, two-way and three-way classifications for one and more than one item in the "classes," graphic interpretations of interactions, analysis of variances by the use of ranges, the meaning of components of mean squares, testing "treatment" averages, tests of homogeneity of variances, estimation of precision of measuring instruments and product variability, lambda tests and multi-vari charts.

Two chapters treat of regression and correlation in which is discussed linear regression, standard deviations of regression coefficients, predicting equations, their confidence limits, regression involvng more than 2 variables, multiple correlation, testing a hypothesis pertaining to multiple regression, the OC curve for a test. Here are presented the least squares method, prediction limits for individual values, the use of analysis of variances for testing regression and coefficients of correlation and non-linear regression.

This is followed by a chapter on the analysis of covariance where fundamental theory is given first by the introduction of models for various classifications, together with the comparisons of the slopes of lines of regression and tests of significance of adjusted averages.

In the sections on designs of experiments the author discusses completely randomized experiments, randomized blocks, Latin squares, Graeco-Latin squares, factorial designs, confounding for a 2^n design, orthogonality, partial confounding and fractional replication with applications.

The last chapter on mapping response surfaces and determination of optimum conditions are well explained with examples.

The Appendix includes 30 important statistical tables, the uses of which are also well explained.

This book, containing such a vast storehouse of information, should be in the library of everyone interested in quality control. It is a classic on this subject.

PRECISION MEASUREMENT AND GAGING TECHNIQUES by William Grohe, Chemical Publishing Co., Inc. New York, 1960 193 pages of text, $7.50. Reviewed by E. R. Conolly, Rich Manufacturing Corp. Battle Creek, Mich.

The writer has prepared this book for the student. As such it would make an interesting manual for use in a vocational school or an in-plant training program.

The text is not written in technical language, therefore is easy to understand. Considerable space is devoted to thread gaging methods and thread measuring devices. Such subjects as: optical gaging, optical flats, indicating gages, fixed gages, torque wrenches, and slide rule are treated rather sparsely.

The illustrations are very good and the book in general has the text appearance of a well written operating instruction manual for the specific products mentioned.

MATHEMATICAL METHODS OF OPERATIONS RESEARCH by Thomas L. Saaty, McGraw-Hill, New York, 1959, page ix-421, $10.00. Reviewed by Herman Rubin, Michigan State University, East Lansing, Michigan.

The book treats some of the mathematical methods in operations research such as difference and differential equations, programmings, game theory and probability. Also, there is an introductory section on the scientific method and model formulation. The section on model formulation is largely devoted to analyses of the models formulated.

The chief objections of the reviewer are that the author does not consider the implications of operations research to statistics and the scientific method, and the corresponding treatment of operations research problems in which information about unknown parameters is being received at the time that actions involved in the optimization occur. For example, the methods in the text would not enable a treatment of continuous sampling, and related problems.

Mid Hudson to Sponsor One Day Seminar At Vassar College, Poughkeepsie, N.Y.

The Mid Hudson ASQC section will sponsor a one day seminar Sept. 17, on "A United Approach to *Product Improvement* Integrated With *Cost Reduction*," at Vassar College, Poughkeepsie, N. Y.

According to Carl W. Wetzel, general chairman, the seminar has been designed to interest quality control and other management and technical personnel in industry, with emphasis on the team approach to problem solving.

J. M. Juran, C. A. Bicking, G. Gilman and E. N. Schrock will cover the management aspects of quality control; F. C. Hartwell and G. Gadzinski will participate along with others on material control techniques, and C. W. Carter and A. B. Mundel will discuss process control.

Topics to be covered during four sessions are: measuring the effectiveness of management; correct budget determination and the relation of management with engineering; statistical auditing techniques associated with supplies conformance; quality specifications and inventory control; process controls as associated with textile, chemical, mechanical and electronic manufacturing; the control of complex assembly operations; product test analysis by variables, and product performance as a measure of overall reliability.

For additional information, contact Casper J. Rose, registration chairman, West Road, Poughkeepsie, N. Y. A fee of $10 covers dinner, transactions, and the seminar. Registration from 9 a.m. to the first session, 9:30 a.m.

Only EX-CELL-O Contour Projectors* Give You ALL!

CHECK THESE FEATURES!

☐ **LARGEST WORK AREA**—Constant eight inches of work space from lens to focal plane regardless of magnification. Plenty of room for large objects.

☐ **UNSURPASSED ACCURACY**—Famed Kodak Ektar® lenses guarantee reliable measurements with clear *accurate* images over entire screen.

☐ **BRILLIANT SURFACE ILLUMINATION**—Original design, "direct-on" built-in surface illuminator gives extra bright image and *full work clearance* at all magnifications.

☐ **ERECT—UNREVERSED IMAGE**—Correct, normal appearing images at all magnifications, eliminate confusion, simplify operation and save time.

☐ **COATED LENSES AND MIRRORS**—Produce clear sharp images characteristic of Ex-Cell-O Contour Projectors. Have been standard on all models for many years.

☐ **BRIGHT, GLARE-FREE SCREEN**—The "Fresnel" lens is exclusive with Ex-Cell-O, permits operator to see entire screen evenly illuminated from normal position. No "hot spots".

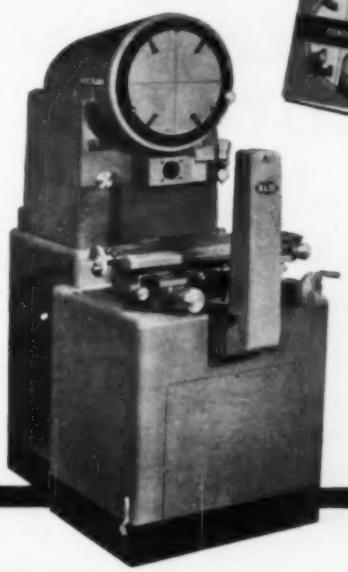
☐ **TRUE MEASURING PRECISION**—All Ex-Cell-O Contour Projectors not only read to tenths—they measure to tenths.

☐ **FINGERTIP CONTROLS**—Ex-Cell-O Contour Projectors are designed for maximum convenience and comfortable all day operation. Easy-to-reach controls.

☐ **RUGGED CONSTRUCTION**—The long established reputation of Ex-Cell-O for precision and quality assures years of trouble free operation.

☐ **YOUR OGP REPRESENTATIVE**—Will help you make sure you get the right Ex-Cell-O Contour Projector to fit your optical gaging requirements. Call him today!

Write for new edition of EX-CELL-O Contour Projector Booklet—Available Now!



*Manufactured by EX-CELL-O Corporation at Detroit, Mich.

SOLD AND SERVICED BY

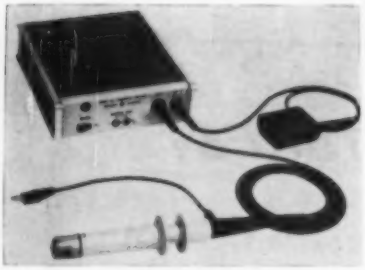
OPTICAL GAGING PRODUCTS, INC.

26 FORBES STREET ROCHESTER 11, N. Y.

(A subsidiary of EX-CELL-O Corporation)

What's New?

ROY A. WYLIE, *Editor*
Ampex Corporation



P-9-4—An instrument which converts ac current to ac voltage for direct reading on a conventional oscilloscope or ac voltmeter is now available from Hewlett - Packard Company. The instrument, Model 456A AC Current Probe, has a probe which clamps around the current carrying wire providing a voltage output which is quickly and easily read on a VTVM or oscilloscope. The instrument's 1 mv to 1 ma unity conversion permits direct readings in milliamperes on voltmeters or oscilloscopes. The Model 456A measures current without connection to the test circuit and with no appreciable circuit loading. Typical applications include measurements on transistors, vacuum tubes and logic circuits. The instrument's wide bandwidth (20 cps to 15 mc) also permits oscilloscope viewing of complex current waveforms with rise times as fast as 0.08 microseconds. The Model 456A simplifies ac current measurements of up to one ampere at frequencies up to 5 mc and at least 100 ma from 5 mc to 15 mc. Model 456A is a compact unit weighing only 3 pounds and is priced at $190.00 and its current availability is 14 weeks.

* * *

P-9-1—A special line of oversize granite surface plates for precision measurement of large parts is now available from The Herman Stone Co. These oversize plates have been designed to meet the needs of heavy machinery and equipment manufacturers requiring accurate and extensive reference surfaces. Constructed entirely in one piece, they eliminate the problems often encountered in lining up several small surface plates to create one large reference surface. The oversized plates are manufactured from Balfour pink and Mt. Airy gray quartz granites to assure dimensional stability and long life. A complete range of plate sizes up to 50 feet long is available.

P-9-7—The Montgomery Universal Bore Gage is a simple holder, to which any "last word" type indicator may be attached. The bore gage can then be used to measure a large range of bores, "O" ring grooves, thread reliefs and undercuts with one low cost tool. The holder is made of steel with a satin-chrome finish. Capacity is from 0.200 inches to 6.000 inches. The price complete with case and extension points is $24.00. Delivery is from stock.

* * *

P-9-10—Ruggedness, durability and accuarcy, have been incorporated into the Wilson Mobile Tester, designed for conducting Rockwell hardness tests on large or bulky metal components and work specimens that have to be tested at their position in open yards, production areas, or are too heavy for economical hauling to a testing station. This direct reading unit can also be utlized in tool departments, maintenance repair shops, inspection departments, etc. The mobile tester consists of a clamping device — C clamps with varying throats — and an indenter head. The clamps have been designed to create a clamping pressure which is sufficient to hold the unit onto the work piece. These clamping brackets, manufactured from aluminum castings, provide an extremely rigid, yet lightweight testing instrument. The unit's minor and major test loads are produced by springs which are preloaded and contained in an individual spring sleeve. For different load ranges, complete spring units are interchangeable. The lightweight tester is avaliable with various clamping designs to assure that it can be applied accurately and easily for all test conditions. Model M-I gives readings in the Rockwell C scale with distance between the anvil and penetrator of 0 to 6.3 inches with a

THE FIVE YEAR INDEX

to

VOLUMES XI-XV

of *Industrial Quality Control* is now available. It has been assembled by the Bibliography Committee in accordance with the Literature Classification System developed by the committee last year. Technical articles in *Industrial Quality Control* are located easily and quickly. Price $1.00

American Society for Quality Control 9-60
161 West Wisconsin Ave.
Milwaukee 3, Wis.

Please send me _____ copies of the Five Year Index to IQC at $1.00.

Enclosed is _____.

Name _____

Address _____

*Trademark

"No more lugging work half a mile to the inspection room—and hefting it back again when it's a little over tolerance— probably cost the company a fortune for all that lost time too.

This gage you can use right at the machine without taking the work off—and check the surface finish right down to a whisker.

They cost little enough to have one at every machine where we do this kind of work.

Is it good? Just look at the specs!"

- 5 Range selections for any precision roughness measurement: 3, 10, 30, 100 and 300 microinches—full scale.
- Roughness width cut-off available in three ranges: .003, .010 and .030.
- Quickly establishes the requirements for each job and allows faster, closer control of the operation.
- Hand held or motor driven tracer.
- Battery or AC line powered units available.

Contact your nearest Cutler-Hammer office for the name of your authorized distributor.

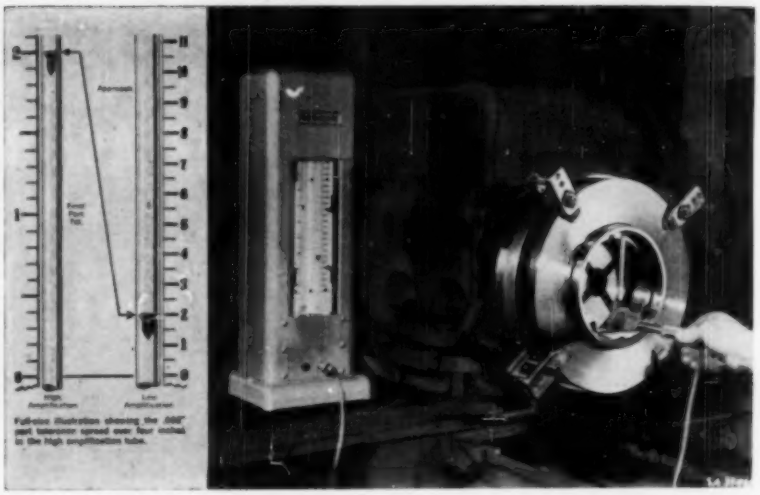
AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, NEW YORK
A DIVISION OF CUTLER-HAMMER INC.

CONTROL

depth of throat of 3.3 inches. Weight is 17 pounds. The Model M-II gives readings also in the Rockwell C scale, with distance between the anvil and penetrator of 0.0 to 9.8 inches with depth of throat of 5.1 inches. Weight is 18 pounds. Accessories such as C "Brale" diamond penetrators, 1/16 inch ball chuck penetrators, test blocks, and calibrated kilogram weights for conducting Rockwell A and B scale tests are available as optional equipment.

* * *

P-9-8—Power transistor measurements from 30 amperes collector current and 300 volt breakdown test potentials are now possible with the new self-contained portable Owen Laboratories type 300 Precision Power Transistor Test Set. Direct meter readings or large signal current gain (H_{FE}) and collector characteristics I_{CBO}, I_{CER} BV_{CBO}, and BV_{CEO}, can be made simply, rapidly, and accurately under conditions typical of their actual applications. The type 300 Test Set is especially well adapted to Quality Control Go No-Go checking of H_{FE}, with preset acceptance values. The set is 17 inches wide, 16 inches high, and 7 inches deep. The price is $675.



P-9-2—In order to speed and improve grinding accuracy to fine tolerances, Sheffield Corporation has developed the "Dual-Amp" Precisionaire. This new gage combines low amplification, long gaging range and high application, close tolerance inspection and automatic sequence. Any time a measurement is made, the right hand column shows part size within the 18 thousandths range and the left hand column spreads the final two thousandths over four inches. For example, a part comes to a grinder with a specified size to within 0.002 inch. Grinding progress through "come-up" or approach is indicated by the descending float in the right hand air tube each time the adjustable 3 to 12 inch diameter Airebore gage is inserted into the part. As the float nears the "2" in the right tube, the one in the left tube descends into view and size within the final two thousandths can be read on that tube with speed and accuracy because it's spread over four full inches. The "Dual-Amp" Precisionaire is available for immediate shipment. It consists of a dual column Precisionaire gage, a special 3 to 12 inch diameter Adjustable Airebore gage, Plunjet, Calibrator, and hose. The price is $910. Existing 3 to 12 inch Airebore gages can be modified to use with the "Dual-Amp" Precisionaire gage by returning the kit to the manufacturer or an interchangeable Plunjet gaging cartridge can be purchased for field installation.

* * *

P-9-3—The new model W-2 impedance analyzer is an inexpensive instrument for precision measurement of polar parameters, phase angle, and ohmic values of impedance of complex networks, iron-core devices, capacitors, etc. It computes and directly indicates phase angle as well as its sine, cosine, and tangent, power factor, Q, and D. These in turn allow the simple calculations of inductance, a-c resistance, core loss, and others.

One of these instrument's advantages is its ability to make these measurements at actual operating values of voltage and frequency of the component under test. Accuracy of at least one percent is attained over a frequency range from 60

Again Available

Transactions of the 1959 Chemical Division
3rd Annual Technical Conference

1959 Transactions include:

Use of Statistical Quality Control Charts in Continuous Chemical Processes, E. S. Aldredge
Some Transformations and Techniques Useful for Graphical Solutions, C. F. Lewis
Determining Sources of Yield Variation in a Multi-step Chemical Process, W. C. Quinn and H. Davidson
Experimental Design — Subdivision of Treatment, M. A. King and F. T. Takenaka
A Field Application of Convariance Analysis, L. D. Pahnke
Effective QC Program for a Knock Rating Laboratory, A. R. Crawford, E. S. McBride and F. W. Kroll
The Grasshopper Program, G. E. Kimball
Estimating the Precision of Test Averages from a Study of Variance Components, E. F. Parmenter
Industrial Application of Non-Parametric Statistics, E. C. Harrington, Jr.
Optical Design Considerations in Response Surface Estimation, J. L. Folks
Variance Components Analysis, A. W. Wortham, J. L. Folks, L. H. Smith
Experimenters, Statisticians and Models, V. B. Shelburne
The Analysis of Means, E. R. Ott
The Analysis of Residuals, L. S. Nelson
Non-Linear Regression, A. W. Dickinson

ASQC, 161 W. Wisconsin Ave. 9-60
Milwaukee 3, Wis.

Please send me .... copies of the 1959 Chemical Division Third Annual Technical Conference Transactions at $2.50 each.

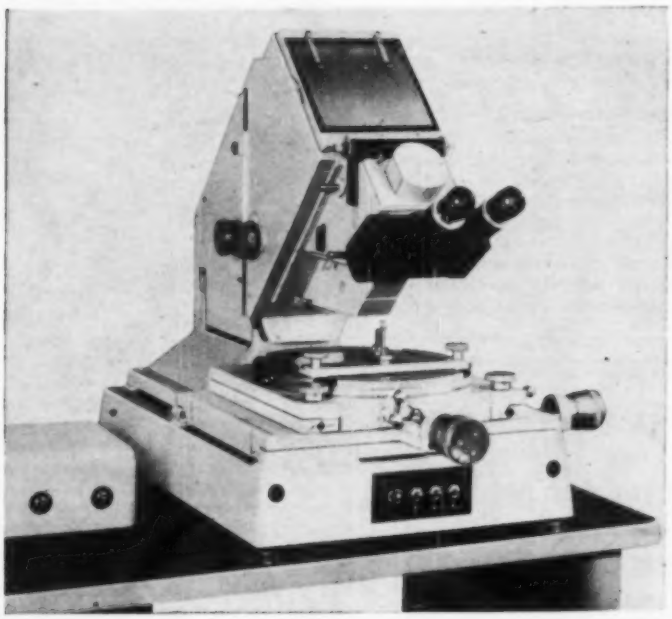
Name .....

Address .....

.....

CHECK FASTER

and with greater reliability of measurement



Made in West Germany

CARL ZEISS

Large Toolmaker's Microscope

This large toolmaker's microscope, made by Carl Zeiss, is a decided improvement over former instruments. It offers greater ease, greater rapidity and greater reliability of measurement.

Has a measuring range of 3x6", permitting extensive application. Its new built-in gauge block displacement device makes it possible to quickly move the stage in the longitudinal direction in five steps and in the transverse direction in two steps, thus eliminating the old fashioned method of interchanging gauge blocks. All manipulations, adjustments and readings are performed from the same position in front of the instrument.

The inclined binocular tube can be tilted and adjusted to suit the convenience of the operator. During tilting, the image in the eyepiece always remains in focus. The object to be tested is seen simultaneously with the crossline of the protractor. The scale of the protractor and templet, however, can be projected consecutively into the eyepiece.

BUILT-IN BEAM-SPLITTING DEVICE

Another novel feature of this instrument is the new built-in beam-splitting device with single or double reversed image in complementary colors for line-symmetrical or center-symmetrical measurements.

A small toolmaker's microscope is also available

Write for literature

CARL ZEISS, INC.

485 FIFTH AVENUE, NEW YORK 17, N. Y.

COMPLETE SERVICE FACILITIES

ASQC Personnel Listing Service

A new service exists for the use of ASQC members only. Any member desiring to be listed as available for new employment opportunities should send a brief resume (on 3 × 5 file card, or cards) to ASQC Personnel Listing Service, Room 6197 Plankinton Building, 161 West Wisconsin Avenue, Milwaukee 3, Wisconsin.

All information will be kept confidential and those listed will be sent descriptions of all suitable opportunities for 60 days following receipt of this initial listing. If it is your desire to remain on the list after this period, you can do so by writing in to the same address and requesting an additional 60 day period. If you do *not* request an extension, your resume will be removed from the file on the assumption that you have made a successful connection.

Companies wishing to post positions available in the ASQC Personnel Listing Service should address all correspondence to the same address as above giving the educational and experience requirements, age and salary limits on each position. The position description should be limited to 100 words plus the complete name and address of the individual to whom resumes should be sent.

cycles to 12 kilocycles. Impedance measurements can be made to one megohm. Accuracy is maintained under conditions of either high or low flux density. The instrument can also be used for tests with superimposed direct current on electrolytic capacitors and for incremental inductance measurements on iron-core components. The compact instrument measuring 8 x 8 x 5 inches is housed in a grey drawn aluminum cabinet which can be used in either vertical or horizontal position.

* * *

P-9-9—The development of the Model 408 Accelerometer, a transducer with a sensitivity of 100 pk mv/pk g designed especially for low level G measurements and vibration studies, has just been announced by Columbia Research Laboratories. The accelerometer has a special case design which permits operation in high intensity noise fields of 160 db and other non-vibrational environments with minimum spurious response. Maximum acceleration of the unit is 10,000 g, frequency response from 1 cps to 3 kc with resonant frequency at 55 kc and amplitude linearity ± 1 percent. Temperature range of the Model 408 is from −60°F to +300°F for standard units and from −65°F to +500°F for high temperature units, with less than ± 10 percent variation in sensitivity throughout both temperature ranges. The case of the accelerometer is a stainless steel ¾ inch hexagon x 0.45 inches high with a threaded mounting stud on the underside of the case. The complete unit weighs just 23.5 grams.

P-9-5—The addition of a true zero adjust to the new design Seegers Standards Precision Test Gauge for proper gauge balance and calibration is announced by Seegers Instrument Company. The true zero adjust eliminates gauge distortion and loss of calibration due to improper starting angle. The precision test gauge, designed for extreme accuracy, permits testing facilities to use the Seegers Standards Precision Test Gauge as a primary standard instead of the average dead weight tester. The accuracy is ± the minor subdivisions over 2. As an example, the 15 psi gauge has a graduation interval of 0.025, which divided by 2 equals ± 0.0125 psig accuracy. Increments on the gauge dials are of equal spacing, with the Bourdon tube calibrated to the dial, allowing recalibration to the same dial. Gauge movement ratios on pressure from 15 psi are maintained to an 8:1 ratio and from 150 psi, a 12:1 ratio is used. The gauges are available in ranges from 0-15 to 0-10,000 psig.

* * *

P-9-6—A new instrument for fast, economical x-ray fluorescence analysis of nearly all elements is announced by Applied Research Laboratories, Inc. One feature of the new instrument is the use of an evacuated chamber so that all elements above atomic number 11 can be quantitatively analyzed in all types of matrices. Prior to this, an inert gas, such as helium, was used

Second Printing . . .

in one compact 12-page reprint you can get the ANOVA material published in the August, September and October 1956 issues of Industrial Quality Control for quick and easy reference.

"Fundamentals of Analysis of Variance"
by Charles R. Hicks
50c per copy

Discount for Bulk Orders: 10 percent for 10 or more copies; 25 percent for 50 or more.

American Society for Quality Control 9-60
161 W. Wisconsin Ave.
Milwaukee 3, Wis.

Send me ..... copies of "Fundamentals of Analysis of Variance."

Enclosed $ .....

Name .....

Address .....

City ..... State .....

Your copy of the 1960 Annual Convention Transactions is waiting for you!

If you were unable to attend this year's convention, you won't want to miss the opportunity of obtaining the vast amount of technical information presented. A limited number of copies of the convention transactions are available on a "first come — first serve" basis. Keep your quality control library up-to-date. Order your copy today!

HERE IS A LIST OF THE PAPERS CONTAINED IN THE 1960 CONVENTION TRANSACTIONS

A Short Survey of Management's Use of Operations Research

Weapons System Management for Quality

The Measurement and Specification of Product Abilities

When is a Small Sample Large Enough?

How to Plan and Implement an Incoming Material Control Program

Statistical Quality Control Applications in the Food Industry

Raising Productivity of Indian Industry Through Quality Control

Calibration Requirements for Government Contractors

Videosonic Instructions Raise Quality Standards

Audit Testing

Variations of Mechanical Properties in Aluminum Products

Air Force Quality Control 1960-1962
Army Progress in Quality Control for 1959
Navy Progress in Quality Control for 1959

Integrated SQC in Food Processing

Some Statistical Concepts Applied to the Navy Calibration Program

Higher Quality—Through—People in Quality—Quality in People

An Approach to a Reliability Prediction Program

Reliability Assurance Provisions in Specifications

Power Characteristics of Control Charts

Life Test—Some Practical Considerations

Good Enough—Isn't Good Enough

Some Economic Aspects of Quality Standards

Quality Control Programs Should Be Cost Reduction Programs

Mechanization, Quality Control and Automation

Company Standards and Quality Control

Automatic Production Recording—Yield—And Quality Control

Sampling Frozen Beef Using a Variable Sampling Plan for Percent Fat

Selection of Flavor Panels for Complex Flavor Difference

How Many Dollars are There in Incoming Inspection Costs?

Total Quality Control Through Reliability

Progress in Professionalism

The Analysis of Variations for Certain Physical Properties of Combed Cotton Yarns

Sampling Problems in the Metals Industry
How Shall We Apply It?
Sampling Problems in the Metal Industries

Statistical Evaluation

A Program for Defining and Controlling Visual Defects in a Multi-Plant Operation

Reliability in Communications and Administrative Applications

50,000 Partners

All This is Yours ... and the price – just $5.00 per copy

This year, for the first time –

Reprints of individual papers are available at only $.50 each. To order, encircle titles and indicate the quantity desired in the margin.

ASQC, 161 W. Wisconsin Ave. 9-60
Milwaukee 3, Wis.

Send me ..... copies of the 1960 Annual Convention Transactions at $5.00 per copy.

Send me ..... reprints of individual papers, as encircled, at $.50 each. I have indicated the quantity desired in the margin.

Amount ..... enclosed.

Name.....

Address.....

.....

ASQC members are entitled to a 20% discount.

Progress with the Society and the field of quality control by enlarging your technical and practical knowledge.

MAIL TODAY!

Stock List

ASQC PUBLICATIONS

Publication	Price
INDUSTRIAL QUALITY CONTROL	
Vols. XIV, XV, XVI (July, 1957—June, 1960) .....Each Vol.	10.00
Individual Back Issues	1.00
(1) Index to Vols. I-X	.50
(2) Index to Vols. XI-XV	1.00
ASQC STANDARD SERIES	
(6) A1-1951 "Definitions and Symbols for Control Charts"	.50
(7) A2-1957 "Definitions and Symbols for Acceptance Sampling by Attributes"	.50
(8) B1, B2-1958 "Guide for Quality Control and Control Chart Method of Analyzing Data" (ASA Standard Z1.1, 1.2-1958)	2.25
(9) B3-1958 "Control Chart Method of Controlling Quality During Production" (ASA Standard Z1.3-1958)	2.50
GENERAL PUBLICATIONS SERIES	
(11) General Publication No. 2, "Manual for Authors of Technical Papers for Publication in Industrial Quality Control"	
(12) General Publication No. 3, "Span Plan Method of Process Capability Analysis"	2.50
(13) General Publication No. 4, "The Power to Detect a Single Slippage and the Probability of a Type 1 Error for the Upper Three-Sigma Limit Control Chart for Fraction Defective, No Standard Given"	2.50
CONVENTION TRANSACTIONS	
(23) Thirteenth Annual Convention "Quality Control Convention Transactions, 1959"	3.50
(24) Fourteenth Annual Convention "Quality Control Convention Transactions, 1960"	5.00
CONFERENCE PROCEEDINGS	
(48) Fourteenth Midwest Quality Control Conference Proceedings, 1959	3.00
(49) Second National Automotive Division Conference Transactions, 1959	2.00
(50) Third National Automotive Division Conference Transactions, 1960	2.00
Second and Third Automotive Division Conference Transactions, when purchased at same time	**3.00**
(51) Third Annual Chemical Division Conference Transactions, 1959	2.50
MISCELLANEOUS	
(76) ASTM Manual on Quality Control of Materials	2.50
(79) NSMPA Manual on Statistical Quality Control Volume 1, "What and Why"	1.50
(80) NSMPA Manual on Quality Control Sampling Volume 11, "Highway Markers to Better Quality"	1.50
(81) NSMPA Manual on Sampling Inspection Volume III, "Do It Yourself Sampling Inspection Installation"	1.50
NSMPA Manuals, Vols. I-III, when purchased at same time	**4.25**
(83) Charles R. Hicks, "Fundamentals of Analysis of Variance," Reprint from IQC Vol. XIII, Nos. 2, 3, 4, August, September, October, 1956	.50
(85) Morris James Slonim, "Sampling in a Nutshell"	1.00
(87) Ralph Allan Bradley, "Determination of Optimum Operating Conditions by Experimental Methods —Part I," Reprint from IQC Vol. XV, No. 1, July, 1958	.15
(88) J. Stuart Hunter, "Determination of Optimum Operating Conditions by Experimental Methods —Part II," Reprint from IQC Vol. XV, No. 6, 7, 8, December, 1958, January, February, 1959	.75
(89) Thomas A. Budne, "Random Balance," Reprint from IQC Vol. XV, No. 10, 11, 12, April, May, June, 1959	.25
(90) Ervin F. Taylor, "File It To Find It . . . the ASQC Literature Classification System," Reprint from IQC Vol. XVI, No. 3, September, 1959	.25
(91) Paul C. Clifford, "Control Charts Without Calculations," Reprint from IQC Vol. XV, No. 11, May 1959	.25
(92) Case Histories on Statistical Methods for Quality Control, by Metals Technical Committee, Series II	1.00

AMERICAN SOCIETY FOR QUALITY CONTROL
6197 PLANKINTON BLDG.
161 W. WISCONSIN AVE.
MILWAUKEE 3, WIS.

Date .....

Please send me the copies of ASQC Publications which I have checked below in quantity as indicated. Enclosed is a check or money order for ..... **(Remittance must accompany orders less than $3.00. Postage is added to orders not accompanied by a remittance.)**

Back Volumes IQC (specify) ..... **Back Issues IQC** .....

(1)	(11)	(49)	(80)	(88) .....
(2)	(12)	(50)	(81)	(89) .....
(6)	(13)	(51)	(83)	(90) .....
(7)	(23)	(76)	(85)	(91) .....
(8)	(24)	(79)	(87)	(92) .....
(9)	(48)			

Name .....
(please print or type)

Address .....

Company .....

City ..... **Zone** ..... **State** .....

Make remittance payable to the American Society for Quality Control, Inc.

Special bulk order discount on any numbered items: 10% for 10 or more copies; 25% for 50 or more copies. New service for individual ASQC members only—20% discount on all numbered publications in any quantity.

for light element analysis, but it is expensive and difficult to obtain. The well known principles of x-ray fluorescence spectroscopy have been followed in the design of the vacuum x-ray quantometer. Special features, however, include high optical speed, both fixed and scanning spectrometers, compactness, and new, efficient sample handling facilities. Both quality control and research laboratories have applications for the VXQ. Accuracy and precision are equal to or better than those obtained with wet chemical methods. Lengthy procedures can be accomplished in only a few minutes by x-ray spectrochemical methods, resulting in savings of time, labor and money.

P-9-11—The new Lufkin Model 202 Measuring Wheel is a time-saving way to measure distance and is designed to quickly measure relatively smooth surfaces. It is ideal for use by paving and construction contractors, industrial maintenance men, police officials, traffic engineers, etc. The 202 Measuring Wheel measures from wall to wall as well as line to line, recording the total distance in feet and inches by a built-in totalizer and the recessed scale on the circumference. An audible click every two feet and a loud bell note indicates the 100 foot mark. Zero reset knob permits pre-setting for a desired distance. The handle extends and locks at 34 inch height, yet it folds for easy and compact storage. It has a fine-quality leather carrying case. Total weight is 2¾ pounds.

New Literature Available

L-9-1—A two-page illustrated catalog sheet now available describes the Type DM-100 Distance Meter, a portable and lightweight precision instrument recently announced by Wayne Kerr Corp. The catalog sheet gives a general description of the distance meter, applications, the operating principle and discusses the instrument's probes and output connections. The instrument is readily adaptable to such specialized purposes as the dynamic balancing of helicopter blades and the measurement of verticality of control rods in nuclear power stations. Other applications include measurement of tool wear, eccentricity, dilation, strain, temperature coefficient of expansion, thickness of plates, dielectric constant, and the inspection of piece parts, as well as all distance measurements where continuous recording and remote indication are required.

* * *

L-9-2—CSI catalog No. 60 contains illustrations and brief descriptions of 77 testers or equipments manufactured as standard products. These units are grouped under the following headings in the index: Abrasion Testers; Biological & Scientific Equipment; Flammability — Ignition Tester; Production, Control and Research Equipment; Thermal Conductivity Dielectric Units, and Thickness Compression and Recovery Gages.

* * *

L-9-3—The new Stokes series of ionization gage controls for the accurate and uniform measurement of ultra-high vacuum are described in a new data sheet, No. 563, which has just been issued. The units provide high stability and extreme accuracy, plus the rugged construction and easy maintenance required in control equipment for industrial instrumentation. In place of bridge circuits, the Stokes units employ electrometer-type amplifiers with negligible feedback and thus provide unusually stable and linear output unaffected by variations in tubes and other components.

* * *

L-9-4—A new eight-page catalog gives full information on various types of Mann Comparators, also the company's background and special precision ruling facilities. These comparators are measuring microscopes to enable photographs on plates or film to be examined and measured with extreme accuracy when mounted on a movable stage which is arranged to traverse one or two coordinates. Measuring comparators are used in missile and satellite tracking, ballistics research, space measurements involving both time and position, and in medical and chemical research. They are also finding increased use in highway layout and planning where measurements from aerial photographs eliminate or reduce conventional ground work.

* * *

L-9-5—Hole location and concentricity gages are shown in a new 8 page Con-Chek gages bulletin. Six standard models of Con-Chek gages with non-rotating pilots and stationary protected indicators are pictured in the bulletin, also six special models for checking large holes, adjacent shoulders, threaded holes, bottom of holes, splined holes, and holes that vary in size.

* * *

L-9-6—Capabilities of, and equipment produced by, the Optics and Metrology Division of Keuffel & Esser Co. are described in a 24-page illustrated brochure. The new division, established earlier this year, specializes in the development and manufacture of optical, mechanical and electronic systems and components for the precise measurement of lengths and angles. Among the systems and components produced by the division and described in the brochure are: Electro-Optical Systems, Angle Transducers, Auto Collimators, Photo-Electric Devices; Optical Systems — Telescopes, Periscopes, Range-Finders, Collimators, Theodolites; Optical Components — Prisms, Lenses, Mirrors, Coatings and Filters, Targets and Reticles, Graduations, angular and linear; Optical Tooling and Industrial Alignment Equipment; Radar and Missile Alignment Systems; Precision Mechanical Components.

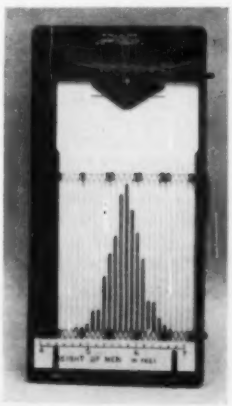
* * *

L-9-7—A new six-page folder which describes the Quality Control methods employed by The Williams-Bowman Rubber Company in their manufacture of mechanical rubber goods is now available from the manufacturer. "Full Cycle" Quality Control is the descriptive name given to the process which begins during rubber compounding and ends when product reliability is assured after final inspection.

USE A QUINCUNX . . . .

to make your quality talk more forceful

to make your in-plant training course more effective



The Quincunx is a must for presentation of basic quality control principles. Demonstrates visually to your audience how a Normal Distribution pattern is formed. Also demonstrates how various Non-Normal distributions are formed.

Lightning Calculator Co.

Box 6192

St. Petersburg Beach 36, Fla.

A delegation from the St. Louis section recently flew from St. Louis to Marion, Ill., to meet with the Southern Illinois section and to present them with their charter. Southern Illinois was formerly a sub-section of the St. Louis section.

section briefs

BATTLE CREEK-KALAMAZOO . . . Since our last meeting of the 1959-60 season, several changes have taken place. Arthur Damon, newly elected chairman, has accepted a position with Minneapolis-Honeywell in Minneapolis, Minn. George Vaught, newly elected section treasurer, has accepted a position with Cooper Tire in Findley, Ohio.

A second election was held in June. Clarence J. Oranje, KVP Sutherland Paper Co., was named chairman; Eugene R. Conolly, Rich Manufacturing Co., vice chairman, and Peter F. Koets, Allen Electric & Equipment Co., treasurer.

During the month of June, E. E. Stephenson, Jr., quality director of KVP Sutherland Paper Co., addressed the Tenth Annual Program of Quality Control for the Graphic Industries, Rochester Institute of Technology, Rochester, N.Y.

Sept. 15, section members will tour the Goodyear Tire and Rubber Co., in Jackson, Mich., with a talk on QC by Cecil M. Noble of the Goodyear Tire and Rubber Co., Akron, Ohio.

BOSTON . . . The Boston section was well represented at San Francisco, with nine members attending the 14th Annual Convention and Exhibition. They were joined there by three former section members.

Dr. Joseph M. Juran was the banquet speaker at the annual management series, which was held at the MIT Faculty Club. This year the series was presented in two parts: the first three days were devoted to a conference program, followed by a two-day seminar.

The first meeting of the 1960-61 series will be held at the MIT Faculty Club on Thursday, Sept. 15, when Dr. A. W. Wortham, director of quality assurance, Texas Instruments, will keynote the 1960-61 program in his discussion of "The Role of QC in Expanding Industry."

New Inspection Techniques Among Topics At Cleveland Convention, Sept. 27-30

New inspection techniques and their effect on mill operators will be the subject of a technical paper to be delivered during the 1960 Iron and Steel Convention and Exposition Sept. 27-30, at the Cleveland Auditorium, Cleveland, Ohio.

The paper will be presented by G. P. Michalos, superintendent of inspection, Steel and Tube Division, The Timken Roller Bearing Co., Canton, Ohio.

CHARLESTON . . . Paul W. Sinsel of the Chesapeake and Potomac Telephone Co., spoke on "New Arts in the Telephone Industry," at the Ladies' Night Meeting May 19. Mr. Sinsel described some of the newer methods, instruments, and techniques that are becoming available now or in the near future.

At another recent meeting of the Charleston section, Richard S. Bingham, Jr., of the Carborundum Co., gave an interesting talk "Studies in Ore Car and Abrasive Grain Sampling Variations." But perhaps of greater significance to the section and ASQC was Mr. Bingham's presentation to the accelerated classes in mathematics at two of the local high schools. Using slides and examples of actual industrial problems, he described the application of statistical mathematics to industry.

Students in the accelerated classes are seniors who will have completed introductory statistics, analytical geometry, and calculus before graduation. Mr. Bingham applied the students present konwledge in these subjects to the problems he discussed and maintained a very keen interest from both groups.

Inasmuch as this experiment proposed by Mr. Bingham was such a tremendous success, he should be commended for offering another first to ASQC. This program will be continued by the Charleston section and extended to college students in the area.

CINCINNATI . . . Saturday, June 4, 1960, was a red letter day for the Cincinnati section and District 8. In the afternoon, the second annual District 8 section officers' meeting was held in Cincinnati. The formal program for the afternoon was made up of presentations by representatives of sections with active programs in the various areas of section activity.

The Cincinnati section discussed Saddoris Award; Lima section — membership, Akron-Canton section —

education programs, and the Dayton section — section programming and conference planning.

It was generally considered that the June 4 meeting was good for ASQC as well as section officers.

In the evening, the annual Dinner-Dance meeting with the Hamilton-Middletown section was held at the Greenhills Country Club.

The 1960-61 program has been completed and will feature a "Ladies' Night" at the September meeting.

CLEVELAND . . . The first executive committee meeting for the coming year was held in the offices of ASQC director Stephen C. Bates of Bell Telephone Laboratories, Cleveland, Ohio.

The discussion included plans for the 1960 All Day Conference Nov. 18, at the Hotel Pick Carter. Three concurrent programs will be held featuring reliability, QC and experimental techniques. Details of the conference may be obtained from Ted Ursa at Thompson Ramo Wooldridge, Cleveland, Ohio.

The education committee announced a series of four programs to be held in conjunction with Western Reserve University. Dr. J. N. Berrettoni of Western Reserve will announce the exact titles of the courses at a later date. The committee also agreed to have the section publish another yearbook. Last year's Yearbook proved very valuable, especially to the membership committee.

COLUMBUS . . . During the annual business meeting June 7, at the Columbus General Depot Officers' Open Mess, officers and committeemen discussed and planned a tentative schedule of activities for the coming year. A very good meal was enjoyed by all.

June 4, R. D. Coffman, T. Royce, and R. Moran represented the section at the ASQC District 8 Conference at the Carousel Motel in Cincinnati, Ohio. District 8 section problems was the topic for the afternoon session.

CUMBERLAND . . . On July 1, our members and guests dined and danced to the music of the Aristocrats at the Shrine Club. It was our annual social event and we had a swingin' time at our "Summer Soiree."

"The Quality Control Man and Public Relations," was the topic of a recent business meeting. The subject was skillfully explored by Bernia B. Lucas, labor relations supervisor, Amcelle Plant, Celanese Fibers Co.

DALLAS-FORT WORTH . . . The section's annual dinner meeting and installation of officers on June 17, was again held at the Western Hills Inn. After a very brief business meeting which consisted of certain annual reports and recognition of both old and new officers, J. Y. McClure introduced Lloyd Turner, who spoke on "Quality in Education," explaining that if we expected to have quality teachers, we may as well expect to pay for them. Mr. Turner is chairman of the Board of Education for Fort Worth Public Schools and is special assistant to the manager of Convair-Fort Worth.

Most of the program has been completed for the 1960-61 year, and should prove to be most interesting. Joint meetings are planned with at least two other societies; one in January with ASA, and one in April with SNT. Also, a joint meeting is planned with the Waco ASQC section in November, and a Management Development Night in December.

DAYTON . . . The Dayton section was represented by James M. Cogar, Chrysler Airtemp Division; Harleigh F. Diehl, DARE, Inc.; George H. Kakehashi, Vernay Laboratories, Inc., and William E. Smith, The National Cash Register Co., at the District 8 meeting for section officers June 4, at the Carousel Motel, Cincinnati, Ohio. Jim Cogar presented "Section Programming," and Bill Smith gave a few pointers from Dayton's successful All-Day Conference of 1960 during the "Conference Planning" session. The meeting was very informative and instructive.

Instructors J L. Massau, left, duPont, T. L. Hebble and C. J. Kennett of Union Carbide review problems in a course in "Correlation and Regression Analysis." It is one of a series of industrial statistical courses sponsored by the Charleston ASQC section for Kanawha Valley industrial employees.

The kickoff meeting for the 1960-61 season will be an informal social gathering Thursday, Sept. 8, at the Delco Lodge on E. Dorothy Lane. Members are urged to bring guests to this get-acquainted session. Good food and an evening of fun for all is promised by the program committee.

GREATER DETROIT . . . Fred Taylor of the Rickel Malt Company spoke at the Master Brewers Association of America meeting in Pittsburgh, June 17. Mr. Taylor spoke about "Basic Concepts of Quality Control," to a group of nearly 100. His talk was well received and reported at length in a national brewing publication.

Another Detroiter who has gone on the road to speak this summer is Ward Mann of Vickers, Inc. Ward spoke before the American Management Association in New York City during a three day session June 27-29, for executive managers.

All members within a 100 mile radius of Ann Arbor won't want to miss the 15th Annual Greater Detroit Forum coming up Sept 10. Dorian Shainin, Les Eichelberger, J. F. Bourquin, and Harmon Bayer will speak. The program will also include six other noted speakers. Certainly this will be an outstanding day to study "Quality Costs," from the inspection, technical, and management viewpoints. For details, write Joe Molnar, Houdaille Industries, 2660 E. Grand Blvd., Detroit 11, Michigan.

HARRISBURG . . . The annual picnic was held June 1, at Gladco Lodge, Spring Grove, Pa., amid a rustic setting on a lake. A delicious chicken and ham dinner, complete with the trimmings, was served family style.

Companies supplied gifts which were given as door prizes to the 100 percent attending members and those attending this meeting. These gifts included such items as liquor, silver candle stick holders, cosmetics, pocket lighters, tire chains, key rings, tie bars and clasps, cufflinks, flashbulbs, and maple syrup.

Officers for the 1960-61 season are: chairman — R. Donsen, Bearings Company of America; vice chairman — H. Gross, RCA; secretary — J. Fasnacht, Hamilton Watch Co.; treasurer — H. Pueschner, Bendix, and past chairman — R. Naylor, Naylor Florist Co.

JOPLIN . . . Victor Burkhart of the Martin Co., Orlando, Fla., is now quality assurance representative at the Eagle-Picher Co., Joplin, Mo. Mr. Burkhart was in the QC group dealing with the Pershing project, and is still

associated with the Pershing project. He is also on the membership committee in the Orlando-Cape Canaveral section.

LEXINGTON . . . The section closed its 1959-60 program year with a dinner-dance at the Lexington Signal Depot Officer's Open Mess. Approximately 100 members, wives, and guests attended. Honored guests included Col. K. M. Gonseth, Depot Commander, and Lt. Col. H. L. Morris, Deputy Commander. Outgoing chairman, Larry Girton, formally transferred the gavel and charter to the new chairman, Don Freeman.

LOS ANGELES . . . *Forty-Eight, 48*, that's the number, 48! The Los Angeles section is having 48 meetings during the coming year. As a result of last year's experience in having separate division meetings, at which great interest and support was received by companies as well as members who had not attended meetings previously, three of the section's divisions will have monthly meetings in addition to the general section meeting. And, each will have a meeting each month from July to June. The Inspection Technical Committee will meet the first week; the Administrative Application Division, the second; Electronics Division, the third, and the General Meeting the fourth. All meetings will be held at the IAS Building, 5660 Beverly Blvd., Los Angeles, Calif. Lester P. Gideon, was selected by the seven sections of District 16, to be the District Representative for the 1960-61 season.

LOUISVILLE . . . The last meeting of the season was held at Jimmy Lynn's Restaurant May 9. Dinner was preceded by a social hour, with cocktails furnished by our education committee. We thank Clayton Lambert for the table favors and the door prize, the latter a Presto blazing torch.

Our newly elected chairman, Warren Allinger, resigned due to a change in job assignment, so our 1960-61 officers are Bill Butler, chairman; Jim Bunch, vice chairman; Ray Evans, secretary, and John Bishopp, treasurer.

Ned Miles, education committee chairman, reported that an intermediate QC course will be offered again next fall. He also announced that more of the QC handbooks are being printed, bringing the total to 300. We are proud of Ned and his gang.

The evening's speaker was James E. Momsma, applied science representative from the IBM Peoria office. He spoke on "Data Processing Equipment," and presented a timely film entitled "Dimension Tolerance Simulation."

Carl E. Noble Receives 3rd Annual RIT Award

Dr. Carl E. Noble has been presented the 3rd Annual Rochester Institute of Technology — Statistical Quality Control award for outstanding contributions to quality control in the graphic arts.

The award was announced during the 10th Annual Program of Quality Control for the Graphic Industries, June 6-10 at RIT.

Dr. Noble was presented the Silver Cup June 30, during ceremonies in the Kimberly Clark main offices in New York City. The Cup was crafted at RIT by Harold M. Kentner, director of the Institute's Extended Services Division.

Past winners of the award are B. E. "Ted" Sooy, A. Curtis and Son, and Donald Macaulay, president of Paper and Printing Quality Control, Inc., Chappaqua, New York.

MEXICO CITY . . . During the month of June, 32 persons, most of them engineers from a number of industries in the City of Mexico and some from industries located in the States of Puebla and Jalisco, attended a course in quality control.

Following the course, certificates were distributed to those whose attendance included no less than 80 percent of the meetings.

The course was sponsored by the Ministry of "Industria y Comercio," and the "Camara de la Industria de Transformacion." We are planning another course for the month of October.

MID HUDSON . . . The first meeting of the 1960-61 season will be held Sept. 6, at 8 p.m., at the DiPrima Hotel in Highland, N.Y. We sincerely feel that this new centralized location will substantially increase our attendance.

Considerable activity is underway in preparation for our one day conference to be held Saturday, Sept. 17, at Vassar College. The program will be diversified and will incude manufacturing engineering, purchasing, sales, and quality control interests.

Carl Wetzel of IBM is general chairman with K. C. Lindermann and Lou Bock assisting.

The following members have been appointed chairmen of the various activities; W. Bobalke, arrangements; C. Shaw, program; C. Pavlakis, publicity; E. Mott, financial; F. Sindelar, speakers; C. Rose, registration; W. Beneshan, facilities, and F. Morgan, exhibits.

NORTHEAST TENNESSEE . . . Although general membership meetings have been discontinued for the summer, the old and new section officers are busy planning next year's programs. The directors, officers, committee chairmen, and their wives met in Kingsport June 28 to plan programs for the coming season. The plans included selection of speakers, training activities, special events, ladies' nights, and two joint conferences to be held at the University of Tennessee and Virginia Polytechnic Institute. The Virginia Polytechnic Conference will be held in the fall and the University of Tennessee Conference will be in the spring. In addition to the plans assigned to officers, all chairmen and officers were given a quota of Saddoris Award points to accumulate throughout the year.

The section was happy to receive the report that it was seventh in the Saddoris Award competition. The Saddoris Award Committee also awarded Master Section status to the Northeast Tennessee section at the ASQC National Convention and Exhibition in San Francisco.

Another meeting for officers, directors, and chairmen is planned for Aug. 30. At this meeting, plans for the September meeting will be made, including planned panel discussions that precede the monthly meetings.

PARKERSBURG . . . Our opening meeting for 1960-61 will be a get-together after the long summer vacation. The Union Insulating Co., Parkersburg, has donated the use of their recreation room for this meeting. So, come one, come all — bring a friend. I'm sure everyone

will enjoy participating in some of the indoor games and observing the programming of activities for the coming year.

PHILADELPHIA . . . The section's Fifth Annual Symposium on Quality Control Methods and Management will be held Sept. 10, at the Philadelphia Textile Institute. The PTI, which was founded in 1884, is the oldest educational institute in the United States devoted to technical preparation of young men and women for careers in the textile and allied industries.

The all-day program from 9 a.m. to 4:30 p.m. will include 14 sessions. The two morning lecture periods are divided into three categories, administration, inspection, and technical, covering six sessions.

In selecting a wide variety of subjects, the committee believes it has penetrated most fields of QC, either directly or indirectly. The committee also hopes to interest people in all levels of QC. No one should leave this Symposium feeling that it was the same old stuff being hashed out again.

The Campus, at School House Lane and Henry Avenue, Philadelphia, has free parking space. Plan now to attend. Price including luncheon and transactions is $7.50.

For advance registration, contact Andrew C. Irvine, 6831 North 9th St., Philadelphia 26, Pa.

PITTSFIELD . . . On June 18, the Annual Outing was held at the Oak 'N Spruce in Lee, Mass. The golf course, swimming pool, and other sports were enjoyed by the excellent turnout of the members and guests. A delicious chicken barbecue was served on the terrace, after which dancing was enjoyed in the Glen room.

An executive meeting was held on June 22, at the Stanley Club, to discuss the program for the coming season.

SOUTHERN ILLINOIS . . . Officers for the coming year are chairman — Cliff Statler, Universal Match Corp.; vice chairman — Virgil Wimmer, Olin Mathieson; secretary-treasurer — Randell Blockley, Sangamo Electric, and director — Charles Rogers, Sangamo Electric.

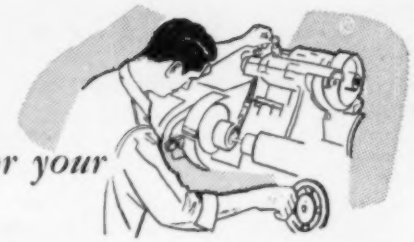
ST. LOUIS . . . Since QC training courses have been so successful in the St. Louis section for the past several years, and because demand continues, two courses will be offered again beginning in September — one basic and one intermediate. An advanced course will be offered in February, 1961.

SAN ANTONIO . . . The last meeting of the season was held June 23, at the Lone Star Brewery picnic area. More than 115 members and guests attended and enjoyed a delicious barbecue chicken dinner and a two hour dancing session "under Texas skies." The agenda for this meeting included the section's annual picnic and installation of officers program. Newly elected officers are chairman — C. C. Brinkoeter, Friedrich Refrigeration, Inc.; vice chairman — J. D. Turner, Kelly AFB; secretary — H. E. Kiker, Kelly AFB, and treasurer — R. V. Short, Kelly AFB.

Program chairmen of the Texas sections have received three commitments thus far from nationally known speakers who will make the circuit tour beginning in September. Commitments from the remaining five speakers are expected to arrive this month.

SYRACUSE . . . A "Ladies' Night" meeting was held June 28 at Turn Hall in Syracuse, Allin P. Deacon, QC consultant of Brantford, Ontario, was the guest speaker. His topic, "What Your Husband Does All Day Long," was very interesting and appropriate.

TENNESSEE . . . The section members enjoyed a dinner meeting June 18. The meeting, held at the Deane Hill Country Club in Knoxville, was the last in the Spring series of "Something for Everyone," meetings. Members and guests enjoyed entertainment presented by a local



For your

High-precision Machines

here's a unique internal gage to

MONITOR THEIR PRODUCTION

Visit automotive transmission plants and you'll find Comtorplugs all along the line . . . used to gage hundreds of internal dimensions with tolerances in close tenths. That's just one example of where Comtorplug puts laboratory precision in the hands of shop people. This is made practical by Comtorplug's unique combination of: Moderate Cost . . . Ruggedness . . . Automatic Accuracy.

Easily readable to 50 millionths
In large .0001" graduations, the pointer provides a FIXED (not passing) size reading.

Uniform accuracy automatically assured
Unique self-aligning, self-centering and uniform gaging pressure guarantee duplication of results free of user influence.

Positive 2-point contact
Reveals front or back tapers, ovality, barrel shape, bell mouth, showing actual amount of deviation.

COMTORPLUG USERS INCLUDE:

Airesearch Mfg. Co.	Douglas Aircraft	Lear, Inc.
Allison Div.	Fairchild Engine & Airplane Co.	McDonnell Aircraft
Apex Electrical Mfg.	Falk Corporation	National Lead
Buick Motor Div.	Ford Motor Co.	Northrop Aircraft
Century Electric Co.	General Electric Co.	Pontiac Motor Div.
Chicago Pneu. Tool	Hamilton Standard Division	Scintilla Magneto
Chrysler Corp.	Harris Seybold Co.	Steel Products Eng.
Continental Motors	Homelite Corp.	Studebaker-Packard
Curtiss-Wright	Int. Harvester Co.	Sylvania (Atomic Div.)
Dana Corporation		United Airlines
Detroit Transmission		Warner Gear Div.

Request Bulletin 50

COMTOR CO., 68 FARWELL ST., WALTHAM 54, MASS.

COMTORPLUG
with interchangeable expanding plugs to gage simple or special bores from 1/8" to 10" dia.

Professional Development Note

Wayne M. Biklen

Wayne M. Biklen has been appointed General Manager of the Staunton, Virginia, operations at American Safety Razor Products, effective June 1, 1960.

Mr. Biklen entered the employ of ASR in 1953 as manager of quality control. He was responsible for setting up this department and when it became a division, he was made director. In 1957, Mr. Biklen was appointed director of engineering, and in 1959 was made manager of operations.

Prior to joining ASR, he was associated with the W. A. Sheaffer Pen Co., in Fort Madison, Ia., where he held the position of manager of quality control.

Wayne has long been well-known to ASQC as a staunch and able supporter and practitioner of QC principles as a decision-making service to management. His promotion to this new and larger responsibility at top management levels brings into these ranks the experience and influence of one more able exponent of total quality control in a professional sense.

Joseph F. Degen, Edward L. Klein

Two members of the Metropolitan section, Joseph F. Degen and Edward L. Klein, have been named vice presidents by Daystrom, Inc.

Mr. Degen is now vice president and general manager of Daystrom, Inc., Weston Instruments Division, Newark and Poughkeepsie.

Prior to his present appointment, Mr. Degen was vice president of operations at Weston, Newark. He joined the company in 1957 as vice president of manufacturing. Earlier, 1946 to 1957, he was general superintendent of the Poughkeepsie, N. Y., plant of the IBM Corp.

Mr. Degen is a member of the American Society of Mechanical Engineers.

Mr. Klein succeeds him as vice-president, operations of Weston Instruments Division, Newark, where he will be responsible for engineering, manufacturing, industrial relations and quality control at Newark, Faraday, Union, and Ponce, Puerto Rico.

Prior to his present position, Mr. Klein served as director of manufacturing from April 1959 and before that as general superintendent. He joined the company in 1952 as assistant foreman of engineering inspection.

He is a member of the Instrument Society of America and the Union Chamber of Commerce.

Robert L. Pappas

Robert L. Pappas has been elected vice president of Ampex Corp. He is also manager of Ampex Military Products Co.

Mr. Pappas was formerly manager of the Ampex quality control division.

He has been with Ampex since 1955, and was elected a corporate officer in 1958. Prior to his association with the Redwood City, Calif., firm, he was quality control manager for Schaible Co., Cincinnati, Ohio.

Mr. Pappas received his engineering degree from Fenn College in Ohio.

His election at a recent meeting of the Board of Directors was announced by George I. Long, president.

artist and heard a very fine talk on QC by Leon Bass. Mr. Bass related instances in his career as a QC engineer that illustrated problems encountered in the various phases of this vocation. A discussion period followed the talk.

TUCSON . . . The first meeting of the 1960-61 season is scheduled for Sept. 28. Since the Tucson section does not maintain social activities and meetings during the summer months, news from this area is also at a standstill. However, the newly elected officers and committeemen are enthusiastically hard at work making arrangements for a truly fine program for the coming year.

WASHINGTON, D.C. . . . Starting Oct. 4, the section will conduct 10 weekly lectures. This series, in effect, will be the second half of the lecture series which was begun last January. The lecturers will emphasize reliability, statistical inference, and operational research. Lecturers will include Ronald Herd, Chester H. McCall, Jr., Howard L. Stier, William J. Youden, Sol Gass, Edward Cushen, and A. C. Rosander. For additional information, contact Howard R. Roberts, phone OLiver 6-1400.

WESTERN MASSACHUSETTS . . . On Sept. 13, the opening meeting of the 1960-61 season will be held at Strathmore Park on the grounds of the Strathmore Paper Co., Woronoco, Mass. The event will kick off with a steak roast at 6 p.m. According to tentative plans, it will be followed by a movie, and a travel talk on South America by Herman Grimmeisen of Gilbert & Barker Manufacturing Co., West Springfield, Mass., a member of the Western Massachusetts section.

WINDSOR . . . The Windsor section had a BALL the night of June 15. Although the caravan made an unofficial tour of the University, it was a RACE to arrive at the point of interest. This was the Hoover Ball & Bearing Co., Ann Arbor, Mich. Dale Cue was the guiding light for the 40 members and guests.

The prime points of interest were a data processing system of control, Tele Control of machine downtime, and the manufacturing of ball bearings. The tour included cold heading, rough grind, hardening, final grind, lapping and the final inspection of the balls. Next, the trip through the inner and outer races departments, and finally the assembly area. Production is held under constant control to assure a standard ball bearing for use in many types of operations.

Mr. Cue emphasized the part that QC plays in this close tolerance industry. Management, supervision, staff, production and inspection and set-up men are all enrolled in a QC course designed to cover their operations.

Significant Differences

. . . Boston — Promotions include: **Billy G. Mercer,** to QC representative, Convair Division, General Dynamics Corp., Pomona, Calif.; **Robert Fabian,** Keystone Manufacturing Co., to inspection supervisor; **David J. Harrigan,** to consultant, QC engineering, Raytheon Co., and **Warren Grosjean** and **Ted Brownrigg,** to Datamatic Division, Minneapolis-Honeywell.

. . . Charleston — **B. C. Wetzel, Jr.,** of duPont has been transferred to the Sales Group of Industrial and Biochemicals, Wilmington, Del. Mr. Wetzel was Saddoris chairman for the Charleston section.

W. A. Aitken, R. M. Berg, and **J. W. Kearns** (and wives) attended the District 8 Annual Meeting on section management June 4, at Cincinnati, Ohio.

. . . Cincinnati — **Bob Johnson,** section chairman, has announced the following appointments to the executive

committee: **Herb Morse,** membership; **Vernon Eklund,** January Conference; **Rudy Gruber,** program, and **Dick Race,** education.

. . . Cleveland — **Al Tashjain,** formerly of Cleveland Welding Co., is now quality manager, Lakewood Manufacturing Company.

. . . Columbus — **Emery Gill,** chairman elect, has resigned due to his transfer to Muncie, Ind., to direct TV bulb parts production for Kimble Glass Co. Mr. Gill was assistant QC supervisor for Kimble Glass in Columbus, Ohio.

. . . Columbus—**Thomas F. Costello** has joined Celanese Fibers Co., as QC engineer of the Textile section of the Amcelle plant. He previously headed the QC department of Talon, Inc., of Stanley, N. C.

Herbert C. Heineman has assumed a new position in charge of the analytical laboratory of Amcel Propulsion, Inc., Asheville, N. C.

John A. Schnelzer has accepted a position as superintendent of QC at the fibers plant of Canadian Chemical, Ltd., of Edmonton, Alberta.

. . . Dallas-Fort Worth — The Saddoris chairman, **Bob Massegee,** recently spent the day with section chairman **Roger Anderson,** at Texas Instruments, to discuss plans for winning first place in the Saddoris competition this year.

Glen Parmeter, section vice chairman, and **Bob Massegee,** Saddoris chairman, both charter members of the Toastmasters Club which was formed late last year, have appeared twice as principal speakers. They took first place each time. Congratulations!

. . . Dayton — **John M. Stanch,** section secretary from Leland Airborne Products Division, AFM, Vandalia, Ohio, is recuperating at home after several weeks in St. Elizabeth Hospital, Dayton, Ohio.

Paul A. Weaver, A. O. Smith Corp., Tipp City, Ohio, suffered a heart attack and is hospitalized at Mary Runyon Hospital, Bellefontaine, Ohio.

Additional company duties at Ledex, Inc., has forced **John W. Webb** to resign as chairman of the membership committee. Appointed to fill that vacancy is **Walter E. House,** Delco-Moraine Products Division, GMC, Dayton, Ohio.

Ray F. Jackson, Mounds Laboratory, Monsanto Chemical Co., Miamisburg, Ohio, has been appointed to head the education committee.

A new service is being offered to Dayton section members in the form of a QC problem consultation service committee. **Robert B. VanLehn,** Vernay Laboratories, Inc., Yellow Springs, Ohio, will head this new committee.

. . . Greater Detroit — **Dr. C. C. Craig** conducted his 13th Annual Intensive Course in QC by Statistical Methods this summer at the University of Michigan.

Bob Vujovich recently moved to Fruehauf Trailer Co., as QC director.

Stan Sherwood will head the newly created reliability staff of General Motors Corp.

Tom Anderson, in addition to his many activities in QC for the Ford Motor Co., and the Greater Detroit section, has been elected the first mayor of one of Detroit's newest suburbs, Southgate, Mich.

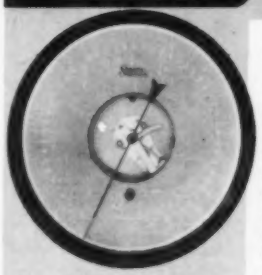
Brant Bonner, Dow Chemical, conducted a special course in Evolutionary Operation recently in Detroit.

Harmon Bayer has been one of the section's busiest members, as he is conducting courses in reliability from coast to coast. Sponsored by ASQC-IRE, reliability seems to be the hottest subject on current QC agendas in many parts of the country. Congratulations to Harmon on a great campaign.

. . . Harrisburg — **Herman Singer** has reported that the education committee has completed plans for presenting three courses. The advanced course will be given by

NOW! TRUE ZERO ADJUST FOR PROPER CALIBRATION

with ALL NEW Seegers Standards PRECISION TEST GAUGE



For critical fluid or pneumatic pressure applications ...where precision accuracy is vital . . . the *all new* Seegers Standards Precision Test Gauge definitely *improves the posture of your testing facilities!*

You achieve the ultimate in extreme accuracy every time! Seegers Standards ZERO REFERENCE ADJUST . . . easily, quickly, positively . . . provides properly balanced precision test gauges . . . calibrated for the optimum of accuracy.

These are truly distinctive Seegers Standards features . . .

- ONLY True Zero Adjust . . . eliminates gauge distortion or loss of calibration due to improper starting angle.
- Accuracy in decimals of psig at any given dial point . . . Ranges from 0-15 to 0-10,000 psig.
- Big, rugged temperature compensating Ni-Span-C Bourdon tube with high spring rate.
- Stainless Steel sockets and tips . . . compatible with various harmful liquids.
- Large eye-ease green dial for at-a-glance pressure readings.
- Precise reading tubular razor-edge dial pointer.
- Center opening dial face . . . shows large precision movement in action.
- Clean, smooth, dustfree design . . . incorporates superior materials with detailed finished workmanship.

Right Now! Write for Seegers Standards TRUE ZERO ADJUST story in new Seegers Standards Precision Test Gauge brochure.

Look to Seegers Standards The World's Finest

SEEGERS INSTRUMENT CO.
511 West Main St., Barrington, Ill.

THE NEW VERSATILE NON-DESTRUCTIVE COATING-THICKNESS TESTER

DERMITRON

Unit Process Assemblies, Inc., pioneers in non-destructive testing and specialists in electronics for metal finishing, offer their latest DERMITRON D-2 with these features:

■ Measures plated coatings on steel, brass, copper, zinc die-cast, aluminum, bronze and other metals; also, nickel on steel. ■ Measures anodize and hard-coat on aluminum and magnesium; also, paint, porcelain, organic coatings on non-ferrous metals. ■ Measures metal coatings on plastics, ceramics and other non-metallic materials. ■ Available with FOUR measuring probes for extra-wide thickness ranges from thin to thick deposits. ■ Only ½" circle area required for measurement. ■ You get fast, accurate, direct readings, plus versatility and portability. ■ Sorts metals and alloys.

Write for latest brochure and questionnaire to help solve your thickness testing problems.

UPA **UNIT PROCESS ASSEMBLIES, INC.**
53-15 37th Ave., Woodside 77, N.Y.

SECTION CALENDAR (AUGUST 25 TO SEPTEMBER 30)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Battle Creek-Kalamazoo	Sept. 15	Goodyear Tire Co., Jackson, Mich.	8:00 p.m.	Plant tour, "QC at Goodyear"	Cecil M. Noble, Goodyear Tire Co., Akron, Ohio.
Boston	Sept. 8	MIT Faculty Club	6:30 p.m.	The Role of QC in Expanding Industry	Dr. A. W. Wortham, Texas Instruments, Dallas, Texas
	Oct. 3	Five consecutive Monday evening sessions	.....	Practical Products Reliability Practices	Dorian Shainin, Rath & Strong, Inc., Boston, Mass
Cincinnati	Sept. 21	Engineering Societies Bldg.	8:00	QC—What is It?	W. E. Barker, General Electric Co., Cincinnati, Ohio
Cleveland	Sept. 9	Cleveland Engineering & Scientific Center	7:45	To be announced	
Columbus	Sept. 21	Columbus General Depot, Officers Open Mess	6:30	QC Applications at Columbus General Depot	Thomas Crull, and John Alden, QMQC Agency
Dallas-Fort Worth	Sept. 22	Arlington State College, Arlington, Texas	8:00	To be announced	
Dayton	Sept. 8	Delco Lodge	7:00	'60 Kickoff Meeting	Get acquainted
Greater Detroit	Sept. 10	Rackham Bldg., University of Michigan, Ann Arbor, Mich.	9:30 a.m.	15th Annual Greater Detroit Forum (on Quality Costs)	Nine speakers
Lexington	Sept. 15	Lexington Signal Depot	7:00 p.m.	To be announced	
Los Angeles	Sept. 27	IAS Bldg.	7:30	Quality Verification Tests	H. D. Mosbenrose, Missile Division, North American Aviation
				Corporate Problems in QC	C. J. Galant, North American Aviation
Northeast Tennessee	Sept. 13	Kingsport, Tenn.	6:00	Fundamentals of QC, With Case Histories	M. L. Snow, Jr., Westinghouse Atomic Power Division, Pittsburgh, Pa.
Mid Hudson	Sept. 6	DiPrima Hotel, Highland, N.Y.	8:00	Random Balance	Dorian Shainin, Rath & Strong, Inc., Boston, Mass.
Philadelphia	Sept. 10	Philadelphia Textile Institute	9:00 a.m.	Fifth Annual Symposium on QC Methods and Management	Several
Syracuse	Sept. 27	Turn Hall, Syracuse, N.Y.	7:00 p.m.	Joint Meeting with the Mathematics Teachers Association of Onondaga County	
Utica	Sept. 15	Hotel Hamilton	8:00	Organization for Maintainability Measurements and Assurance	M. S. Marcus, Emerson Corp., Jersey City, N.J.
Western Massachusetts	Sept. 13	Strathmore Park, Strathmore Paper Co., Woronoco, Mass.	6:00	Steak roast with travel talk and movies	

Ervin Taylor, Martin Co., Baltimore, Md., and the basic and intermediate courses will be conducted by **James T. Skelton,** Caterpillar Tractor Co., York, Pa. Section members are reminded to return their enrollment cards.

Harold Reehling, program chairman, Armstrong Cork Co., reports that his committee has completed the program, which will soon be published.

. . . Lexington — **Glenn Padgett,** vice chairman, and **Roy Harney** represented the section at the District 8 section management meeting June 4, in Cincinnati, Ohio.

. . . Los Angeles — **Joe W. Loesch,** Hughes Aircraft Co., recently was promoted to quality manager, reliability and quality general office. Joe was formerly superintendent of assembly inspection and test at Hughes, Tucson, Arizona.

W. E. (Bill) Drees, vice chairman of the inspection sub-committee, has left Arnoux Corp., as chief of quality assurance to become sales engineer with Thomas L. Stevens Co., inc.

R. H. (Dick) Myers, formerly of Magnovox Research Laboratories, has returned to the reliability and quality general office of Hughes Aircraft Co., as manager of reliability.

Irving Quardt, chairman of the Electronics Division, Los Angeles section, is now a senior engineer in the reliability group of the Norair Division of Northrop Corp. He was formerly an electronic engineer in quality control for the U.S. Air Force.

Dr. Harry G. Romig, QC and reliability engineer, has been appointed to the staff of Operations Research Inc., as senior scientist. Dr. Romig will be instrumental in setting up programs of reliability assurance for the military and industry and will be located at the Corporations Western Division office at 1314 Westwood Blvd., Los Angeles 24, Calif.

James Wills has been appointed QC manager for the Electro-Mechanical Division, American Electronics, Inc. He succeeds George Schulte, who now is chief quality engineer.

. . . Northeast Tennessee — **Ralph DeBusk** attended a two-week QC course at Purdue University, June 7-17.

Dr. Hubert Hill, section chairman of the board of directors, attended a two-week course on "Modeling and Simulation in Operation Research," at the University of Michigan from June 13-24.

A. G. Dawson, section member, has resigned his position as inspection methods engineer at Raytheon to accept an appointment as chief inspector for IT&T, Roanoke, Virginia.

. . . Mid Hudson — During the coming months efforts will be made to review the membership and to upgrade all who qualify.

. . . Tennessee — This summer **Dave Chambers** has been working at various plants of the Celanese Corp.

Roberta McCutchen and **Boyce Cotton** are working on the new publication of the Technical Societies Joint Council. The council includes professional organizations in the Oak Ridge area.

. . . Tucson — **Joe W. Loesch,** newly elected section chairman, has been promoted to manager of quality for Hughes Aircraft Co., and has been transferred from Tucson to Culver City, Calif., to maintain this office. **E. L. Fellnew** is the new section chairman, with **R. C. Bunker** as vice chairman.

. . . Windsor — The chairman of the Windsor section is now with Ford Motor Co., Toronto, Congratulations and good luck, **Roy Mackay.**

ASQC Announces

ADMISSION TO GRADE OF MEMBER
(as of July 1, 1960)

ADELL, ALBERT, Flushing, N. Y.
ALLEN, ROBERT M., Bucyrus, Ohio
ANDERS, ROBERT V., Little Rock, Ark.
ANSELMO, ALEXANDER B., Mattapoisett, Mass.
ARDEN, FREDERICK R., Clifton, N. J.
ARRIS, GEORGE E., Gahanna, Ohio
ASATO, CHARLES K., Los Angeles, Cal.
AUDETTE, RAYMOND P., Lodi, N. J.
BAISHIKI, SADAO, Santa Cruz, Cal.
BALZER, EUGENE, Morristown, N. J.
BARBE, MARTIN, Los Angeles, Cal.
BLIZZARD, THOMAS C., Mansfield, Ohio
BAUER, TED W., South Bend, Ind.
BARNHART, FOREST E., Ashland, Ohio
BIDERMANN, WILLIAM R., Northridge, Cal.
BILIKAM, JOHN E., Dayton, Ohio
BLOCK, ARNOLD H., Pacific Palisades, Cal.
BOERS, WALLACE W., Encinitas, Cal.
BOLLINS, HOWARD E., Torrance, Cal.
BOWMAN, HOWARD J., JR., El Centro, Cal.
BOYD, WILLIAM A., Salt Lake City, Utah
BRADLEY, WOODROW W., Lenoir City, Tenn.
BRODERSON, MILTON T., San Carlos, Cal.
BROWN, WILLIAM M., JR., Methuen, Mass.
BUJAK, HENRY C., Detroit, Mich.
CAMPBELL, DAVID T. H., Cleveland, Ohio
CARPENTER, BRYANT L., N. Wilbraham, Mass
CARSON, VAUGHN W., Cheshire, Conn.
CASAVANT, WALLACE J., Spencer, Mass.
CLIFGARD, CURTIS B., River Grove, Ill.
COLMAN, ARTHUR R., Montreal, Que., Canada
COMISKEY, JOHN A., Ann Arbor, Mich.
CONLEY, JOSEPH E., Garden Grove, Cal.
COSTON, THOMAS R., San Francisco, Cal.
MINER, FLOYD G., Denver, Colo.
BURNS, ROSS J., Houston, Texas
DALE, WARREN T., Monrovia, Cal.
DOYON, LEONARD R., Sudbury, Mass.
[illegible], ROY E., Minerva, Ohio
FREEMON, MILLARD S., Mansfield, Ohio
GABOR, PETER, Garfield, N. J.
GARDNER, DOUGLAS S., Cornwall on the Hudson, N. Y.
GASSMANN, MARTIN T., Sparta, N. J.
GEORGE, PETER J., South Bend, Ind.
GORMAN, HOMER L., Jamestown, Ohio
HAGERMAN, DOUGLAS C., Edmonton, Alta., Canada
HAIGH, WALLACE G., Bridgeport, Conn.
HALDIMANN, RENE R., Signal Mt., Tenn.
HALL, GERALD L., Los Angeles, Cal.
HALLOWELL, ALBERT G., Reseda, Cal.
HARTER, MILLARD J., West Salem, Ohio
HESELTON, HARRY E., San Carlos, Cal.
HEFFELFINGER, BERNARD E., York, Pa.
HOLDEN, JOHN A., Dorval, Que., Canada
HORNBY, J. WILLIAM, Springfield, Mass.
HUDDLESTON, ROBERT E., Fairfax, Va.
HUFFMAN, DONALD E., Mansfield, Ohio
HUTINGER, JACK H., Jennings, Mo.
JACKSON, LYLE R., Arvada, Colo.
JACOBS, EVAN T., Toronto, Ont., Canada
JOHNSON, NELS O., Bridgeport, Conn.
KENDRICK, ALBERT R. JR., Ashfield, Mass.
KING, RUSSELL C., Jackson, Mich.
KLING, WALTER A., Chattanooga, Tenn.
KNECHT, ROBERT M., Elgin, Ill.
LE MASTERS, HERBERT H., Ashland, Ohio
LILLEVICK, ROBERT H., Montebello, Cal.
MATTOS, ANTON, N. Olmsted, Ohio
MCCHESNEY, ROBERT D., Hayden, Ariz.
MCKNIGHT, CHARLES, Downey, Cal.
MORAN, JOHN B., St. Louis, Mo.
MOORE, RAYMOND S., Rowley, Mass.
MOSER, CLIFFORD M., Orange, Cal.
O'NEILL, EDWARD F., Valhalla, N. Y.
PETRO, ANDREW J., Montreal, Que., Canada
PHILLIPS, BILLY M., Manchester, Ga.
PHILLIPS, DONALD E., Syracuse, N. Y.
POYTER, JOHN D., Ottawa, Ont., Canada
POWERS, ROGER P., La Porte, Ind.
RADCLIFFE, JOHN C., Tempe, Ariz.
RAHMAN, KHALIL-UR., Karachi, West Pakistan
REDLINE, PAUL E., Baltimore, Md.
REHKOPF, ROBERT P., Lock Haven, Pa.
REIGLE, JOHN, Louisville, Ky.
REINICKE, HERBERT G., Galion, Ohio
RIDGELL, CAMERON H., Opelika, Ala.
ROOSE, THEODORE V., Mishawaka, Ind.
ROTH, RONALD C., Clinton, Iowa
RUE, HERMAN D., Culver City, Cal.
SAUBER, WILLIAM J., Midland, Mich.
SEIPPEL, ARTHUR B., Baltimore, Md.
SHERMAN, MORTON H., Chicago, Ill.
SIMMONS, LEON F., Meriden, Conn.
SMALLWOOD, GUY R., Painesville, Ohio
SMITH, STANLEY W., Granada Hills, Cal.

statistical

engineering

consultant

Exceptional opportunity for qualified engineer to participate in the varied and vital activities of a progressive nationally known multi-plant company. Work will include consulting in the statistical methods and implementation of operations analysis, reliability, product quality, data systems and related fields. Excellent starting salary and opportunity for advancement. Liberal fringe benefits. Location: upstate N.Y.

Send resume in confidence to:

F. J. Moles

General Engineering Laboratory

GENERAL ELECTRIC

Schenectady, New York

Basic QC Course to Begin Sept. 13

A 16 week course in basic statistical quality control will begin Sept. 13, at the University of Illinois — Navy Pier.

Classes will meet in room 213 from 7 to 10 p.m. No pre-requisites are required, and the fee will be nominal.

The course, sponsored by the Chicago ASQC section, will be conducted by a section member, Gilbert Sorbor, who has conducted similar courses at various educational institutions—most recently at Northwestern University. Mr. Sorbor is a senior QC engineer with Western Electric.

For additional information, contact Bob Williams, Kellogg Switchboard, 6001 W. 51st St., Chicago 38, Ill., telephone RE 5-5445, Ext. 46.

QUALITY CONTROL

Testing Machines for

- *RESEARCH*
- *DEVELOPMENT*
- *QUALITY CONTROL*

ISN'T IT TRUE?

The technical man well knows that the prudent selection of a quality control test helps maintain high product standards and eliminate costly rejections.

- **Manufacturers**
- **Distributors**
- **Custom Designing**
- **Repair**
- **Calibration**

1079 Testing Machines available from TMI. Ask for our New 224 Page Catalog and Register of Testing Machines.

tmi TESTING MACHINES, INC.
72 Jericho Turnpike, Mineola, New York, U.S.A.
"Our Forty-second Year"

Classified Advertising

Positions Wanted: ASQC Members 75¢, non-members $1.50 per line. Minimum space 5 lines, maximum 20 lines (2½ in. high).

Positions Available: $1.50 per line. Minimum 5 lines, maximum 20 lines. Box permissible if desired on maximum size. General advertising rates apply to all display sizes (1/6 page minimum).

38 characters and spaces per line. Replies to box numbers and copy should be addressed to American Society for Quality Control, 161 W. Wisconsin Ave., Milwaukee 3, Wis. Deadline is 22nd of second month preceding publication.

POSITIONS AVAILABLE

Quality Managers
Quality Control Engineers
Reliability Engineers
Professional placement service by specialists in these fields. Many fee-paid positions. Send resume, salary, geographic preference to:
Quality Control Personnel Service
267 Hawthorne St.
Malden, Mass.

QUALITY CONTROL ENGINEERS

A leading multi-division company offers openings at staff level for trained quality control engineers with 3-5 years experience, preferably in chemical, paper or textile fields. Work involves process studies, capability analyses, preparation of process, test and inspection specifications, planning and supervision of designed experiments. Extended educational benefits. Send complete resume to

Mr. H. A. Pilkey
Manager Salaried Personnel
The Carborundum Company
Niagara Falls, New York

QUALITY CONTROL STATISTICIAN

Research position for a trained statistician with 2-3 years experience in statistical quality control. Should have some training in chemistry or chemical engineering. Work will involve the application of statistical quality control techniques to the sugar refining process. Also included will be statistical design of experiments and analysis of test data.

Send resumé and references to the California and Hawaiian Sugar Refining Corporation, Crockett, California, L. B. Drury, Personnel Manager.

QUALITY CONTROL ENGINEER—Man to manage plant quality control department. Position will require development of the organization in modern quality control engineering methods and the application of scientific techniques for the appraisal and control of product quality from design characteristics to field experience. Product involves mass production of metal parts. Please send resume including salary required and snapshot if available to Box 17Q1.

QUALITY CONTROL:

Position for person with strong statistical quality control experience. Chemistry, Chemical Engineering, or paper industry background helpful. Prefer college graduate with at least three years' experience. 30-35 years of age. Salary commensurate with experience. Send resume and salary requirement to:

Industrial Relations Manager
West Virginia Pulp and Paper Company
Luke, Maryland

Product Education Service

These advertisers provide educational information on their products, expanding the services of your journal, *Industrial Quality Control*.

Their support is twofold. First they place the latest information on product development at your finger tips. In addition their purchase of advertising space supports your Society and this publication. Continue to advance your Society by using their products and services and encourage others to do so. They all merit your consideration.

When writing or talking to advertisers to inquire about their products, always remember to say you saw their ad in *Industrial Quality Control*.

Advertisers in This Issue

A-1	Airborne Instruments Laboratory	39	A-13	Lightning Calculator	45
A-3	Bell Telephone Laboratories	1	A-25	Lockheed Missiles and and Space Division	28-29
A-4	Cadillac Gage Co.	IBC	A-31	Optical Gaging Products	37
A-5	Comtor	49	A-15	Remington Rand Univac	11
A-9	Elliott Service Co.	35	A-17	Seegers Instrument Co.	51
A-11	Jones & Lamson Machine Co.	BC	A-28	Testing Machines, Inc.	53
			A-19	Unit Process Assemblies Incorporated	51
			A-21	Carl Zeiss, Inc.	41

Advertisers in Previous Issues of Volume XVII

American Optical Co.
Abbeon, Inc.
Airborne Instruments Laboratory
Bell Telephone Laboratories
Cadillac Gage Co.
Celanese Fibers Co.
General Electric Co., X-Ray Dept.
Interscience Publishers, Inc.
Lufkin Rule Co.
Mayes Tool Co.
Monroe Calculating Machine Co.
Sheffield Corp.
HRB—Singer, Inc.
Veeder-Root, Inc.
Western Electric

Mail the handy coupon below to obtain further information about any of the items appearing in advertisements or new products and new literature described in the **"What's New"** department, pages 38-45.

INDUSTRIAL QUALITY CONTROL
Room 6197 Plankinton Building
161 West Wisconsin Avenue
Milwaukee 3, Wisconsin

Att: Product Education Service, 960

Please send me further information as indicated below:
(mark key number of advertisements, new products or literature)

ADVERTISERS	NEW PRODUCTS	NEW LITERATURE
A—	P—	L—
A—	P—	L—
A—	P—	L—
A—	P—	L—

Name _____

Address _____

_____

City _____ Zone No. _____ State _____

clinics, conferences, and courses

AUGUST

. . . **29-Sept. 5**—The American Mathematical Society will hold its annual Summer Meeting at Michigan State University, East Lansing, Mich., in conjunction with the Mathematical Association of America and the Society for Industrial and Applied Mathematics. Contact the American Mathematical Society, 190 Hope St., Providence 6, R. I.

SEPTEMBER

. . . **1-3**—European Organization for Quality Control Conference, "Controlling Product Quality—Its Value to Industry," Church House, London, contact British Productivity Council (EOQC 1960 Conference), 21, Tothill St., London, S. W. I., England.

. . . **7-9**—First Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass., sponsored by ISA, AIChE, AIEE, ASME and IRE, contact Dr. James Mozley, Johns Hopkins University, Baltimore, Md.

. . . **10—Fifteenth Annual Forum, sponsored by the ASQC Greater Detroit section at the Rackham Bldg., University of Michigan, Ann Arbor, Mich. This is a one day forum of unusual and basic QC techniques. Contact Jack Diggs, 31783 Scone, Livonia, Mich.**

. . . **10—Rutger's Quality Control Conference at Rutgers • The State University, New Brunswick, N. J., contact Wm. F. Frey, Bristol Laboratories, Elmsford N. Y.**

. . . **10—Fifth Annual Symposium on Quality Control Methods and Management with the Philadelphia Textile Institute as host, contact Stanley Hart, Esterbrook Pen Co., Camden, N.J.**

. . . **11-23—Eleventh Annual Basic Statistical Quality Control Institute sponsored by the ASQC Southern Connecticut section. Contact Richard M. Story, Jr., Box U-41, University of Connecticut, Storrs, Conn.**

. . . **12-16**—Technical Report Writing course for engineers and scientists, contact University of California, Extension Division, Los Angeles 24, Calif.

. . . **17—One Day Quality Control Conference at Vassar College, Poughkeepsie, N.Y., sponsored by the Mid Hudson ASQC section, contact Carl W. Wetzel, IBM Corp., Plant 2, South Road, Poughkeepsie, N.Y.**

. . . **20-21**—During the coming academic year Carnegie Institute of Technology will offer, in its evening program, two-semester credit courses in experimental design, probability and mathematical statistics, and quality control and industrial statistics. The courses will meet one evening a week, Monday, Wednesday, and Friday evenings respectively, 7:30-10:30 p.m., September, 1960 through May, 1961. Registration for the courses will be Sept. 20-21, from 6:30-9:00 p.m. For further information regarding graduate and undergraduate day courses, write to Edwin G. Olds, Department of Mathematics, Carnegie Institute of Technology, Pittsburgh 13, Pa.

. . . **21-22**—Ninth Annual National Symposium on Industrial Instrumentation, Manger Hotel, Cleveland, Ohio, sponsored by AIEE–IRE. Program will include two sessions on measuring devices and one each on data handling devices and process control and techniques. Contact J. V. Werme, Bailey Meter Co., 29801 Euclid Ave., Wickliffe, Lake Co., Ohio.

. . . **21-23**—Conference on problems of power generation and transmission, Philadelphia, Pa., sponsored by the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The conference is open to non-members of the societies upon payment of a registration charge of $8, and to members for a fee of $5. Contact L. S. Dennegar, ASME, 29 West 39th St., New York 18, N.Y.

. . . **26-30**—Instrument Society of America Fall Instrument-Automation Conference and Exhibit and 15th Annual Meeting, New York Coliseum, New York, N. Y., contact Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

. . . **27-30**—Exposition and Convention sponsored by the Association of Iron and Steel Engineers at the Cleveland Auditorium, Cleveland, Ohio, contact Association of Iron & Steel Engineers, 1010 Empire Building, Pittsburgh 22, Pa.

. . . **27-29**—Eleventh Annual Testing Conference sponsored by the Technical Association of the Pulp and Paper Industry (TAPPI), Pantlind Hotel, Grand Rapids, Mich. A symposium will be conducted on the testing of "Water—the Most Important Non-Fibrous Raw Material." Contact TAPPI, 11th Testing Conference, Pantlind Hotel, Grand Rapids, Mich.

. . . **30-Oct. 1—Evolutionary Operations (EVOP) Course sponsored jointly by the ASQC Chemical Division and the ASQC South Texas section at the Ben Milam Hotel Houston, Tex. Instructors will be J. Stuart Hunter, University of Wisconsin, and Truman L. Koehler, American Cyanamid Co. Course fee is $100.00, and registration will be limited to 50 persons. Contact Jim C. Deland, Shell Oil Co., P. O. Box 2527, Houston 1, Tex.**

OCTOBER

. . . **4-7**—Tenth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Md., sponsored by the Washington sections of the American Association of Clinical Chemists, American Chemical Society, Instrument Society of America, Society of American Bacteriologists, Society for Experimental Biology and Medicine; primary topics include fluorescence, infra-red, activation analysis, ultra-centrifuge, microscopy and electrodes. Contact Herman C. Ellinghausen, Agricultural Research Center, U. S. Department of Agriculture, Beltsville, Md.

. . . **5**—Plastics vs. Corrosion, a Regional Technical Conference sponsored by the Golden Gate section of the Society of Plastics Engineers, contact Douglas H. Wright, chairman, registration committee, c/o Hewlett-Packard Corp., 1701 Page Mill Road, Palo Alto, Calif.

. . . **6-8—Fourth ASQC Workshop - Seminar, Statler Hilton Hotel, St. Louis, Mo., Paul C. Clifford, director, professor at Montclair State College. Address inquiries to: Fourth ASQC Workshop-Seminar, ASQC, 161 W. Wisconsin Ave., Milw. 3, Wis.**

. . . **10-12**—16th Annual National Electronics Conference, Sherman Hotel, Chicago, Ill., sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern and Illinois Universities. Participants incude Iowa State, Notre Dame and Purdue Universities, Michigan State, Wayne State, Michigan and Wisconsin Universities, Electronic Industries Association and Society of Motion Picture and Television Engineers. Contact NEC, 228 N. LaSalle St., Chicago 1, Ill.

. . . **10-13**—Tenth Corrugated Containers Conference, Royal York Hotel, Toronto, Canada, sponsored jointly by the Technical Association of the Pulp and Paper Industry (TAPPI), New York, and the technical section of the Canadian Pulp and Paper Association (CPPA), Montreal. This will be the first such conference to be held in Canada. Contact H. O. Teeple, TAPPI, 360 Lexington Ave., New York 17, N.Y.

. . . **10-15—Reliability Training Conference at the Lake Texhoma Lodge near Kingston, Okla., north of the Dallas-Fort Worth area, sponsored by the ASQC Electronics Division and the PGRQC of IRE, contact Art Roddey, registration chairman, Institute for Defense Analysis, The Pentagon, Washington 25, D. C.**

. . . **14-15—Fifteenth Midwest Quality Control Conference, Wichita, Kans., contact Ralph D. Humphries, Cessna Aircraft, Wichita, Kans.**

. . . **14-15**—Symposium sponsored by the Society of Photographic Scientists and Engineers in Washington, D.C., on short access time, compact, simplified photographic processing equipment, contact Society of Photographic Scientists & Engineers, Box 1609,

Metals Technical Committee Meeting Oct. 20-21

The annual meeting of the ASQC Metals Technical Committee was held May 24, at the Sheraton-Palace Hotel, San Francisco, Calif.

The officers were unanimously re-elected to serve a second term as no other nominations had been received by R. H. Ede, United States Steel Corp., chairman of the nominating sub-committee.

Officers are chairman — Thomas P. Davis, Allegheny Ludlum Steel Corp., vice chairman — Oscar H. Bishop, Reynolds Metal Co., and William E. Bramer, John A. Roebling Sons Corp., and secretary — George F. White, Jr., Reynolds Metal Co.

The next meeting will be held in Cleveland, Ohio, Oct. 20-21, 1960, with W. T. Rogers, National Tube Division, U.S. Steel Corp., as host.

Main Post Office, Washington, D.C.

. . . **19-21—Fourteenth New England Quality Control Conference, Hotel Bancroft, Worcester, Mass., contact Francis B. Olsen, Norton Company, New Bond St., Worcester, Mass.**

. . . **19-26**—INTERKAMA, 2nd International Congress and Exhibition for Instrumentation and Automation, Duesseldorf, Germany. For information, admission tickets, and room reservations, contact the German American Chamber of Commerce, 666 Fifth Avenue, New York 19, N. Y.

. . . **20-22**—Seventh International Meeting, Institute of Management Sciences, for administrators and scientists in the field of management, Hotel Roosevelt, New York, N. Y. Registration fees—members $15, non-members $20, students $5. Contact James Townsend, 30 East 42nd St., New York 17, N. Y.

. . . **23-27**—15th Engineering Conference, Robert Meyer Hotel, Jacksonville, Fla., sponsored by the Technical Association of the Pulp and Paper Industry (TAPPI), contact Eleanor Ney Wark, Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York 17, N. Y.

. . . **31-Nov. 2**—13th Annual Conference on Electrical Techniques in Medicine and Biology, Sheraton Park Hotel, Washington, D.C., sponsored by ISA, AIEE, IRE, contact Dr. R. L. Bowman, National Heart Institute, Bethesda 14, Maryland.

. . . **31-Nov. 5**—One-week course in packaging management, Hotel Astor, New York City, sponsored by the American Management Association. Contact American Management Association, 1515 Broadway, Times Square, New York 36, New York.

NOVEMBER

. . . **3-4—Fourth Technical Conference, Chicago, Ill., sponsored by the ASQC Chemical Division, contact Karl J. Bauer, Abbott Laboratories, North Chicago, Ill.**

. . . **11-12—Eighth Annual Aircraft and Missiles Division Conference and Middle Atlantic Conference, Lord Baltimore Hotel, Baltimore, Md., contact Stanley Kalin, Dept. 251, Bendix Radio Corp., Baltimore 4, Md.**

. . . **15-16**—Symposium on Engineering Applications of Probability and Random Function Theory, Lafayette, Ind., sponsored by Purdue University. The symposium will stress applications of probability and random function theory Contact J. L. Bogdanoff or F. Kozin, Symposium co-chairmen, Division of Engineering Science, Purdue University, Lafayette, Ind.

. . . **18—All Day Conference on Quality Control and Reliability, sponsored by the Cleveland ASQC section, at the Pick-Carter Hotel, Cleveland, Ohio, contact L. S. Nelson, General Electric Co., Nela Park, East Cleveland 12, Ohio.**

DECEMBER

. . . **13-15**—Tenth Annual Eastern Joint Computer Conference (EJCC), Hotel New Yorker and Manhattan Center, sponsored by the National Joint Computer Committee, which consists of representatives of the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Association for Computing Machinery. Abstracts of technical papers proposed for the conference should be submitted by Aug. 13, to the technical program chairman, Elmer C. Kubie, Computer Usage Co., Inc., 18 East 41st St., N. Y. 17, N. Y. Subject matter should concern recent achievements or techniques in the design and use of computing equipment. Contact P.O. Box 2580, Grand Central Station, N. Y. 17, N. Y.

JANUARY

. . . **9-11—Seventh National Symposium on Reliability and QC, Bellevue-Stratford Hotel, Philadelphia, Pa., sponsored by the IRE, AIEE, EIA, and ASQC. Contact R. L. Schwerin, vice chairman, publicity committee, Emerson Radio and Phonograph Corp., Jersey City 2, N. J.**

. . . **16-19**—ISA Winter Instrument-Automation Conference & Exhibit, Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis, Mo., contact William H. Kushnick, executive director, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

APRIL

. . . **12-14**—Third Symposium on Information and Decision Processes, Purdue University, Lafayette, Ind. Contact Purdue University.

ASQC Annual Convention
Future Dates

June 5-7, 1961	**Philadelphia**
May 23-25, 1962	**Cincinnati**
May 20-22, 1963	**Chicago**
May 4-6, 1964	**Buffalo**

Consulting Services in Quality Control
Since 1945
RALPH E. WAREHAM
Fellow, ASQC
122 Orchard Ridge, Chappaqua, New York
Telephone CEntral 8-3715

FRANK H. SQUIRES
Fellow, ASQC
Consultation
Reliability Organization
Quality Control System
Cost Control
Surveys, Training
4700 Crenshaw Blvd.
Los Angeles 43, Calif.
AXminster 1-3213

VENDOR SURVEYS-INSPECTION
A National Organization with Engineers in Nine Key Centers Coast to Coast.
Write for Schedule of Fees
R. CALVERT HAWS, Member, ASQC
QUALITY CONTROL ENGINEERS, INC.
6399 Wilshire Blvd., Los Angeles 48, Calif.

Quality Control Consultant
HARMON S. BAYER
Fellow, ASQC
1154 Book Building, Detroit 26, Michigan
Telephone WOodward 5-3796

CONSULTING SERVICES
Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisemnts. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society. Business card ads are available only to members of the Society—12 insertions $75.00; 6 insertions $50.00.

EDWARD A. REYNOLDS
Fellow, ASQC
LIGONIER, PA.

Quality Control Consultant
THOMAS A. BUDNE
Fellow, ASQC
3 Dunster Road Great Neck, N.Y.

QC Planning Defect Prevention
LEONARD A. SEDER
FELLOW ASQC
267 HAWTHORNE ST.
MALDEN MASS.
DAvenport 4-5446
Organizing for Quality Training

BERNARD HECHT
Quality Control & Reliability Specialist
Fellow, ASQC
Planning and Staffing Q. C. Organizations
Training in Statistical Methods
Quality Assurance Programs
5410 Wilshire Blvd. Los Angeles 36, Calif.
WEbster 8-0121

Management Controls
FOUNDED IN 1948
References and Literature on Request
Senior Partner:
W. E. JONES
Fellow, ASQC
999 Rose Ave.
DES PLAINES, ILL.
Vanderbilt 4-1317

R.R. 3, Box 258
Greenwood, Indiana
SUTHERLAND-JACOBSON & ASSOCIATES
Consultants in Quality Control
Inspection Procedures, Process Controls, Statistics for Research and Development
M. L. SUTHERLAND, Ph D., Fellow ASQC
H. J. JACOBSON, Fellow ASQC

Products of Precision by CADILLAC GAGE

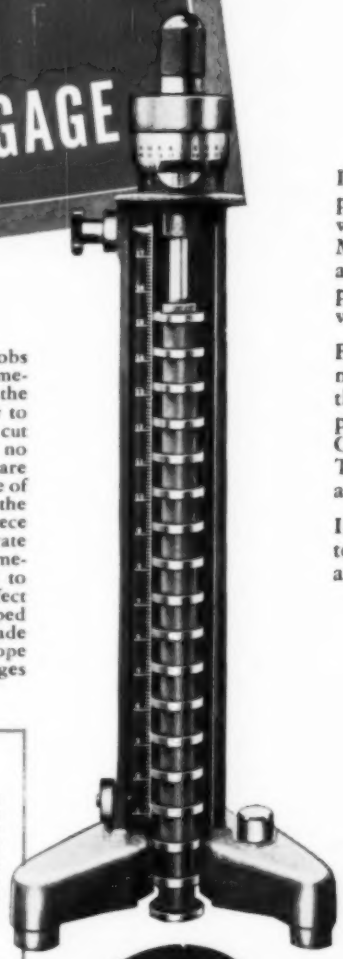
If it's precision you want—guaranteed precision—you've come to the right place when you specify Cadillac Gages and Measuring Instruments. For Cadillac is a name built over the years on accuracy, precision, quality, long instrument life, value and economy.

From the famous PLA-CHEK Gages, now proved in hundreds of plants throughout industry, through the complete line of Thread Ring, Thread Plug, Cylindrical Ring, Cylindrical Plug, Pipe Thread and Concentricity Gages, neither accuracy nor quality is ever sacrificed.

If your operations require really close tolerances, specify Cadillac Gages . . . and get guaranteed accuracy.

PLA-CHEK GAGES

In thousands of installations on innumerable jobs PLA-CHEK Gages are daily proving their time-saving and money-saving advantages, both at the surface plate and the machine. Extremely easy to operate—and fast, too,—PLA-CHEK Gages cut inspection time from minutes to seconds with no loss of accuracy. No auxiliary gage blocks are necessary. PLA-CHEK'S measuring bar is made of deep-frozen, strain-free alloy steel. Steps on the bar are exactly 1" apart. Because of its one-piece construction, steps cannot change or separate with age. Adjustment of the bar is by the micrometer thimble at top. Since it is not necessary to touch the measuring bar, body heat cannot affect it. All reference surfaces are ground and lapped to extremely close tolerances. Precision-made risers, which give PLA-CHEK even more scope and are engineered as accurately as the gages themselves, are available for all models.



COMPLETE RANGE OF SIZES

PLA-CHEK Gages are available in a full range of sizes to meet every inspection or surface plate layout requirement. Models are: The easily portable 6", 12" and 18" sizes, each guaranteed accurate throughout its entire range to .00005"; the 24" guaranteed to .0001" over its entire range; and the 36" and 48" sizes guaranteed accurate to .0001" in any 24" length or .0002" over their entire range.

CYLINDRICAL RING GAGES

Deep frozen for stability and long life, Cadillac Cylindrical Ring Gages reproduce assembly conditions exactly.

THREAD PLUG GAGES

Full length of gaging member is available for inspection. Worn or damaged end may be reversed in collet. Available in a full range of sizes.

THREAD RING GAGES

Manufactured of the finest alloy steel, these gages are heat and cold-treated for maximum stability. They are carefully lapped and closely inspected under controlled conditions.

CYLINDRICAL PLUG GAGES

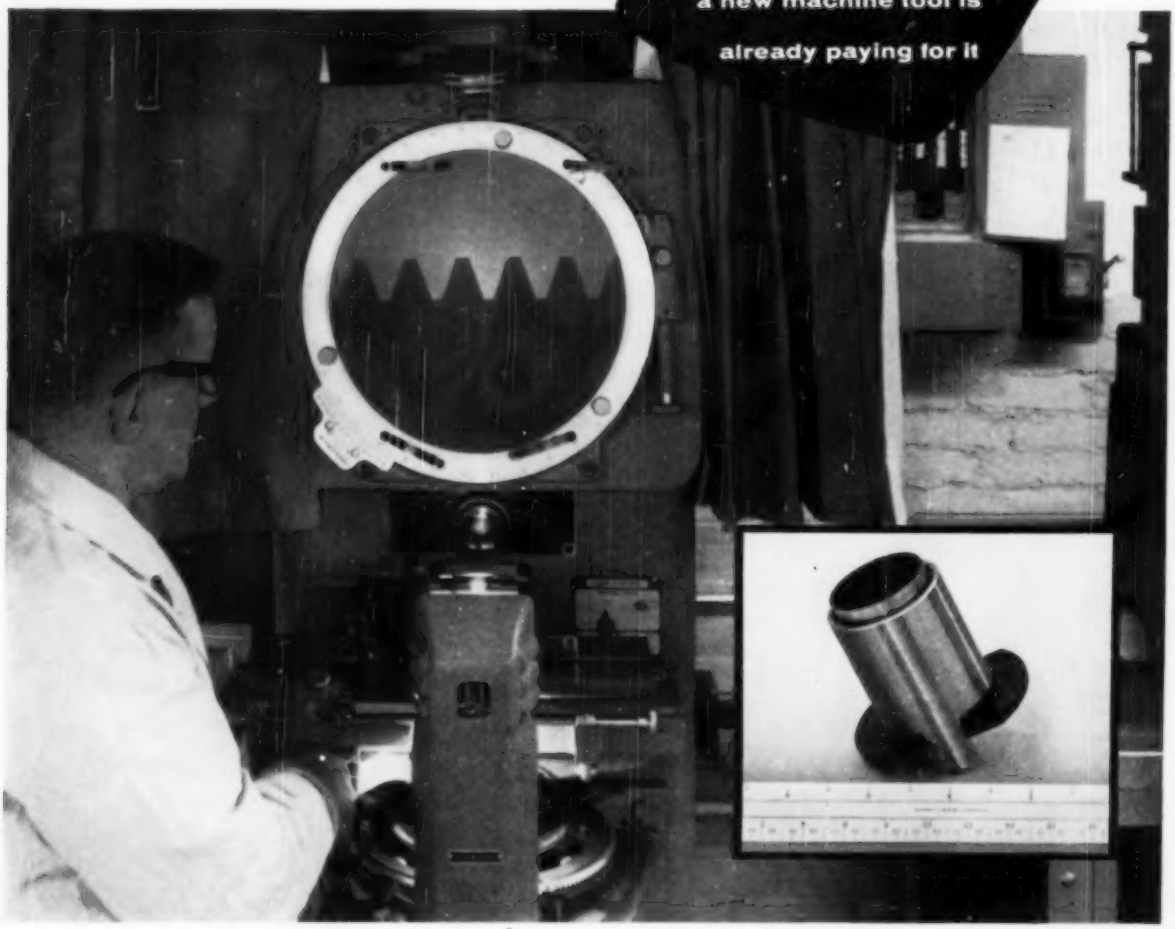
Available in a full range of sizes, these cylindrical plug gages provide unconditionally guaranteed accuracy.

Cadillac GAGE COMPANY

P.O. BOX 3806 • DETROIT 5, MICHIGAN

JONES & LAMSON
OPTICAL COMPARATORS

the man who needs
a new machine tool is
already paying for it



Unretouched photo (above) shows this cylindrical rack being inspected at 62.25X. Photo, courtesy of Baird-Atomic Inc., Cambridge, Mass.

4000% Increase in Inspection Efficiency through use of a J & L Optical Comparator

Baird-Atomic, Inc., Cambridge, Mass., manufacturer of scientific and research instruments needed a rapid and precise method for the quality control measurement and inspection of various components. After experimentation with various types of inspection equipment, a J & L FC–14 Optical Comparator was given a trial. It met all requirements perfectly.

The inspection of a cylindrical rack, heart of the Baird-Atomic Periscopic Sextant, used in advanced aircraft, gives an illustration of the J & L Comparator's efficiency.

The rigid quality control tolerances for this part include: tooth-to-tooth tolerance, .0002″; tooth-to-tooth error, .0003″; composite error, .0003″; pitch dia. within .0005″; concentricity within .0005″ TIR.

Adequate inspection and measurement by conventional methods proved laborious and time-consuming: inspection rate was little better than one rack per day. Now, using a J & L FC–14 Optical Comparator, average inspection rate is 42 per day, an increase of approximately 4000%!

Investigate the possibilities of J & L Comparators in *your* production set-up. Available in 12 different models, both floor and table types.

Write today for Comparator Catalog 5700. Jones & Lamson Machine Company, 510 Clinton Street, Springfield, Vermont.

Turret Lathes • Automatic Lathes • Tape Controlled Machines • Thread & Form Grinders • Optical Comparators • Thread Tools